SUGARBEET RESEARCH

1965 REPORT

Compiled by Sugarbeet Investigations

CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

CR-4-66

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Crops Research Division
Beltsville, Maryland

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1/ This progress report of cooperative investigations contains data, the interpretation of which may be modified with additional experimentation. Therefore, publication, display, or distribution of any data or statements herein should not be made without prior written approval of the Crops Research Division, ARS, U.S. Department of Agriculture, and the Cooperating Agency or agencies concerned.

CR-4-66

F O R E W O R D

SUGARBEET RESEARCH is an annual compilation of the research accomplishments by staff members of Sugarbeet Investigations and Cooperators. The data in most of the progress reports are later used in the preparation of comprehensive manuscripts for technical publications.

The Report presents results of investigations strengthened by contributions received under Cooperative Agreements between Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation; the Farmers and Manufacturers Beet Sugar Association; and Union Sugar Division, Consolidated Foods Corporation.

At Salinas, California, research is further strengthened through contributions from the California Beet Growers Association, Ltd.

TRADE NAMES occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture.

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HIGHLIGHTS OF ACCOMPLISHMENTS

A. Breeding and Genetics

Yellows Resistance.--Two items of breeder seed (C413 and C4742), which are resistant to viruses inducing yellows of sugarbeet, were made available to cooperators for seed increase and utilization in their breeding programs (p.8). C413 was derived from US 75 by McFarlane and associates through 5 successive generations of selecting for yellows resistance. Under severe yellows exposure, the damage was about half of that suffered by the parental variety US 75 (p.18). In field trials by McFarlane, Skoyen, and Hecker, experimental monogerm hybrids in which C413 was pollen parent were good in beet yield, sucrose percentage, and resistance to curly top and bolting (p.61). At Davis, Calif. (p.306, 1964 Report), C4742 ranked first in tolerance to yellows in a field trial of 17 inbred lines. It has only fair resistance to curly top and bolting. C4742 was selected from hybridization of NB1 and IRS-55M14.

IRS Lines.--IRS-55M14 and 49 other IRS lines of sugarbeet breeding material developed in virus yellows research at the Instituut voor Rationele Suikerproductie, Bergen op Zoom, Netherlands, were generously made available (1955) for use of Sugarbeet Investigations by Dr. Henk Rietberg, Director of the Institute. In his letter of January 7, 1966, Dr. Rietberg stated: "We have decided to donate to Sugarbeet Investigations all breeding material available at their stations that has its origin from the Instituut voor Rationele Suikerproductie at Bergen op Zoom. Such under the condition USDA will list this material as a normal release to the Beet Sugar Development Foundation and that it will be subsequently utilized in the manner that is normal for releases by the USDA." C4742 derived its yellows resistance from IRS-55M14.

Vulgaris-Patellaris Hybrids.--Helen Savitsky reports continuing progress in the production of F_2, b_1, and b_2 generations from the F_1 of sugarbeet X viny species of Beta (Section Patellares). The transfer of genetic factors conditioning extreme resistance to the cyst nematode in the viny species is emphasized in the research. Approximately 1,800 plants of F_2, b_1, and b_2 progeny were inoculated with viable cysts of *Heterodera schachtii*. Those that did not show signs of infection were reinoculated. In one F_2 progeny, 12 plants showed unusual resistance--6 remained free of encysted nematodes after the third inoculation. These plants have a peculiar phenotype. Helen Savitsky found fundamental differences in the structure of inflorescences of monogerm sugarbeet and *Beta patellaris* which preclude this wild species as another source of the monogerm seed character (p.92).

Vulgaris-Corollinae Hybrids.--A higher level of resistance to the curly top virus resides in species of the Section Corollinae than in cultivars of *Beta vulgaris*. The late V. F. Savitsky obtained hybridization of sugarbeet (4*n*) and *B. corolliflora* (n = 18). Bennett inoculated plants of

b_1 progeny with a virulent strain of curly top virus (p. 99). Thirty-two plants did not develop observable symptoms of infection, and 29 of these remained symptomless after reinoculation. The resistant segregants and the susceptible segregants in the b_1 progeny were examined cytologically by Helen Savitsky and, as expected, proved to be triploid or aneuploid (p. 98). The majority of the plants in the group highly resistant to curly top had 27 chromosomes; however, there were 3 with 26, 2 with 28, and 1 with 24 chromosomes. The b_1 progeny resembled B. corolliflora. The plants were male sterile, but the majority of them produced some seed when pollinated by diploid sugarbeet.

Male Sterility.--Genetic studies by Theurer and Ottley (p. 125) failed to provide a satisfactory explanation for the partial pollen fertility frequently encountered when utilizing cytoplasmic male sterility of sugarbeet. F. V. Owen recognized the advantages of broadbase hybrids; and the lack of a pollen restoring line lead him to propose the use of both cytoplasmic (CMS) and Mendelian (aa) sterility as a means of producing double crosses. Theurer found several pollen-fertile lines that fully restore pollen production in the offspring when used as pollinators of male-sterile lines (p. 132). He diagramed a scheme for the use of type O, CMS, and restorer lines in the production of double cross hybrid seed (p. 133).

Graft Unions.--Seedling grafts in tests by Hecker (p. 269) did not result in transmission of cytoplasmic factors conditioning pollen production. The selfed and hybrid progenies of the scions supplied no evidence of transmission, through the graft, of factors determining pollen sterility or fertility. Theurer and Ottley are continuing investigations on the possibility that cytoplasmic factors in certain parentage may segregate in generations following grafting (p. 131). Smith reports marked deviations from the phenotypes expected in F_2 and b_1 progeny involving the a gene conditioning pollen sterility in the sugarbeet (p.145).

Population Genetics Pertaining to Sugarbeet Breeding.--From the evaluation of several sugarbeet breeding methods, Hecker (p.283) concluded that recurrent or recurrent reciprocal selection provides the best method of improvement in sucrose percentage and also offers the most promise for advancement in beet weight. Improvement should be possible with various mass selection schemes, although theoretically they are less effective. The need for large populations in a breeding program is emphasized by the determination that only 2 plants in 10,000 in the population under study were expected (with a probability greater than 0.999) to be genetically superior in both sucrose percentage and beet weight. The isolation and crossing of genetically superior individuals for salient characteristics should result in populations where recurrent or recurrent reciprocal selection could be effectively practiced and inbreeding should provide parental lines for the production of superior hybrids.

Computer Calculations.--Milliken (p. 273) developed a computer procedure for the calculation of coefficient of thin juice purity. Where computer service is available, the procedure can result in a saving of time and reduce the likelihood of errors. Computer services are used in statistical analyses of data obtained in variety trials by Ryser (p. 148), Hogaboam (p. 330), and Hecker et al. (p. 241).

B. Variety and Quality Evaluation

Monogerm Hybrids.--Performances of experimental monogerm hybrids (monogerm male sterile X multigerm pollinator) show continuous improvement over standard multigerm varieties. Of special interest are the 3-way hybrid (562 X 569) X C413, which manifests yellows resistance acquired from the pollinator, C413, and the 3-way hybrid FC (502/2 X 504)MX X FC 901, which is resistant to both leaf spot and curly top. The facility with which hybrids can be modified through choice of parental components has enabled the breeder to produce monogerm varieties to meet regional requirements. In 1965, the national sugarbeet seed crop was 99.3% monogerm (p. 14). This noteworthy achievement of providing the American sugarbeet growers with adapted monogerm seed, which facilitates mechanization of field practices, was brought about through cooperative efforts of Federal and sugar industry scientists.

Variety Trials in the Great Lakes Region.--Regional evaluations of hybrid varieties have been continued by Hogaboam, Coe, and Mumford (p. 330) in cooperation with the research staff and company members of Farmers and Manufacturers Beet Sugar Association. In acreable yield of beets, hybrid SL(129 X 133)MS X SP 6322-0 ranked first among the entries; but it was not significantly superior to (SP 6121 X EL31)MS X SP 6322-0, which had the same pollinator. This multigerm pollinator, SP 6322-0, produced a more productive hybrid with a male-sterile monogerm F_1 than did SP 5822-0. Hybrid (SP 6121 X EL31)MS X SP 6322-0 was generally the best in quality as measured by calculated pounds of recoverable sucrose per ton of roots. It ranked second in acreable yield of recoverable sucrose. Forty experimental hybrids were evaluated for leaf spot resistance in three geographical areas. The hybrid with best leaf spot resistance was not the same for each location; therefore, varietal evaluations for leaf spot resistance should be made in areas of intended use.

Polyploidy.--Several diploid lines, which are important parents of hybrid varieties, were made autotetraploid by Hammond (p. 53) and H. Savitsky (p. 90). In cooperative field trials by McFarlane, Skoyen, and Beatty (pp. 26,43), experimental polyploid hybrids involving Hammond's tetraploid lines have not demonstrated performances superior to those of related diploid hybrids. Poor quality of seed, probably due to ineffectiveness of tetraploids as pollinators, is a depreciating characteristic

of the polyploid hybrids (pp. 17,90). The ease with which the sugarbeet can be autotetraploidized with colchicine has facilitated programs of breeding. For example, Hammond established a homozygous diploid line from a haploid sugarbeet (pp. 8,58); and H. Savitsky (p. 91) and V. F. Savitsky (p. 98) used tetraploid sugarbeet in the production of fertile interspecific hybrids.

C. Diseases and Their Control

Yellows Resistance.--Infection by the yellows viruses usually results in yellowing of leaves; the degree of yellowing, however, is not a reliable indication of the extent of damage. The reduction in productivity caused by virus infection is therefore used to appraise resistance. When a split-plot design is used, the plants in half of a plot are inoculated with the virus; and plants in the other half are kept as free as possible from infection through control of the vector (*Myzus persicae*). Extensive field tests at Davis, Calif., by McFarlane, Skoyen, and Hecker, show continuing progress in the development of resistant lines (p. 61). Fife (p. 75) indicated that selections for yellows resistance can be made on the ratio of amino acid concentration in infected leaves. Hecker (p. 69) did not establish that the condition of the chloroplast in yellows infected plants could be used as a criterion of resistance.

Leaf Spot-Curly Top Resistance.--Extensive regional trials of experimental hybrids and commercial varieties, by Gaskill et al. (p. 173), demonstrated the excellent performance of the male-sterile monogerm F_1, FC (502/2 X 504)MS, as female in hybridizations with complementary pollinators. This F_1 is resistant to leaf spot but susceptible to curly top. The best hybrid performances were obtained when FC 901, multigerm, which is excellent in curly top resistance (Fig. 1, p.229) and moderate in leaf spot resistance, was used as pollinator. In cooperative tests at 13 locations in 9 States, the average percentage and gross yield of sucrose for FC (502/2 X 504)MS X FC 901, expressed as percent of the corresponding averages of the standard variety, were 102.5 and 108.4, respectively. Under severe leaf spot exposure at Fort Collins, Colo., this hybrid exceeded the local check by 8.9% in acreable yield of gross sucrose. Observational tests revealed that several of Gaskill's new type O or near type O monogerm lines carry resistance to both leaf spot and curly top.

Curly Top Resistance.--Although the curly top virus and its vector, *Circulifer tenellus*, abound in the Rocky Mountain and West Coast regions, the use of resistant varieties prevents severe damage to the sugarbeet crop in these regions. The occurrence of more virulent strains of the virus requires constant vigilance and continual evaluation of breeding material. The field procedures developed by A. M. Murphy for curly top intensification consist of intercalating infected plants in the experimental plots as a source of primary inoculum and as food for the vectors that immigrate into the field. Numerous entries of breeding material,

especially new monogerm lines, are evaluated annually for curly top resistance by Murphy (p. 102) in tests at Thatcher, Utah. According to research of Schneider and Murphy (pp. 109,166), preliminary screening for curly top resistance can be conducted effectively in the greenhouse.

Nematode Resistance.--Whitney and Doney (p. 83) have further evaluated the sugarbeet breeding material developed by Charles Price, who had selected from populations grown under exposure to a disease complex induced by soil inoculum containing viable cysts of the nematode (*Heterodera schachtii*) and other soil pathogens. Twenty-eight items were evaluated in soil heavily infested with the nematode and fungous pathogens. About three-fourths of the selections outyielded US 41, the commercial standard used by Price; six outyielded US 75 which gave better performance than US 41 in this test. A correlation of r = .92 was obtained between beet yield and nematode cyst populations, and a correlation of r = .72 was obtained between beet yield and the number of sugarbeet plants that died between singling and harvest. The nematode is thought to be a predisposing factor to attack by other pathogens and not wholly responsible for the death of plants.

Rhizoctonia Resistance.--Gaskill used his rosette method of inoculating populations of sugarbeet with *Rhizoctonia solani* in an effective program of screening and selecting for resistance to the pathogen. The establishment of a principle and a procedure for breeding sugarbeet for resistance to this ubiquitous pathogen is a significant accomplishment. Gaskill has shown that breeding for Rhizoctonia resistance is feasible and that resistance may be manifest in both beet size and plant survival (p. 231). Sugarbeet lines differ markedly in response to selection for resistance. A remarkable level of Rhizoctonia resistance was achieved in SP 641004-02 (Fig. 2, p. 239).

Storage Rot Resistance.--Mumford, Filban, and Hogaboam found that the low nitrogen nutrition, which enhanced quality, predisposed beets to rot (p. 374). They used *Botrytis cinerea* as the test organism. Chemical changes in beets during storage reduce resistance to the pathogen. The simple Botrytis method of evaluating for rot resistance is especially suited to breeding material, because sampling for the laboratory test does not result in serious injury to the beet.

Cercospora Leaf Spot. -Leaf spot surveys conducted by Calpouzos and Stallknecht (p. 359) in the Red River Valley and in southern Minnesota reveal that in 1965 the disease was not severe in the region. The results of their fungicidal treatments show the importance of early applications when conditions are favorable for disease development. Coe (p. 405) found that the amount of damage caused by the disease is related to the tolerance of the variety; but under conditions especially favorable for disease development, a significant amount of damage may be caused in the most resistant cultivars of sugarbeet.

Virus Diseases.--Duffus and Gold (p. 381) report that aphids (*Myzus persicae*) feeding through a membrane on a purified plant extract containing Western beet yellows virus are more efficient vectors than aphids feeding on juice of infected plants. The density gradient method of purification of the plant juice is used in studies on the properties and characterization of the virus. Ruppel (p. 387) neutralized the inhibitor of cucumber mosaic virus, which occurs in sugarbeet juice, by phenol-buffer extractions.

D. Physiology and Biochemistry

Physiological Investigations.--Snyder (p.392) confirmed his previous finding that harvest prior to full maturity resulted in slow and incomplete germination of sugarbeet seed. From several years of study on nitrogen nutrition, he concluded that for Michigan an application of nitrogen in excess of 90 pounds per acre is not likely to give a favorable response in recoverable sucrose per ton or per acre. Problems in purity determinations and in calculation of recoverable sucrose have been discussed by Snyder (p. 392) and by Stout (p. 166).

Nature of Leaf Spot Resistance.--In 1960 Harrison, Payne, and Gaskill reported that a phenolic compound in leaves of sugarbeet was associated with resistance to *Cercospora beticola*. The oxidation products of the phenolic compound are highly toxic to the pathogen. Gardner identified the compound as 3-hydroxytyramine. Polyphenolase, a naturally occurring enzyme in sugarbeet leaves, is capable of oxidizing 3-hydroxytyramine. Based on these findings, a working hypothesis for the biochemical mechanism of leaf spot resistance in the sugarbeet has been investigated by Harrison, Maag, Hecker, and Collins (pp. 241-268). They found an association between leaf spot resistance and high concentration of 3-hydroxytyramine (p. 268). Chemical genetic studies indicate that simultaneous improvement can be more easily achieved in sucrose percentage and 3-hydroxytyramine or in beet weight and the compound than in sucrose percentage and beet weight combined (p. 242.)

Sampling.--Plant material shows wide variations in 3-hydroxytyramine with environment, plant development, and age of leaves of the same sugarbeet (p. 255). The young leaves contain more 3-hydroxytyramine than the older leaves. Leaf injury increased the concentration of the phenolic compound. Resistance to the pathogen may depend on the ability of a plant to synthesize the toxic substance in response to injury more than on the naturally occurring concentration of the compound in leaves. These investigators also found deviations from the expected relationship of the concentration of 3-hydroxytyramine, the oxidizing enzyme, and leaf spot resistance (p.254). Further research is being conducted to establish an acceptable biochemical explanation of leaf spot resistance in the sugarbeet.

Summary of Accomplishments prepared by Dewey Stewart.

PART I

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase 1965
and
Utilization and Distribution of Items

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Seed Production of 1964 Items

PRODUCTION OF MONOGERM SEED IN U.S.A.

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase
June 3, 1965

Breeder seed, inbred lines, and experimental hybrids, which have been developed in the breeding research conducted by the staff of Sugarbeet Investigations, are proposed for seed production through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These new productions of breeding research have been developed by the staff of Sugarbeet Investigations in work conducted under Cooperative Agreements with:

California Agricultural Experiment Station
Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Minnesota Agricultural Experiment Station
Utah Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corp.

Items Proposed for Seed Increase and Utilization

I. U.S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane, B. L. Hammond, I. O. Skoyen, and R. J. Hecker.

Item 1. C4633 Monogerm . . . . 50 grams

A type O, monogerm inbred selected from the second backcross to the multigerm NB1 inbred. C4633 is similar to NB1 in both curly top and bolting resistance.

Suggested utilization: Use as a breeding line. Not recommended for increase until more information on performance is available.

Item 2. C4742 Multigerm . . . . 50 grams

A yellows-resistant inbred selected from IRS 55M14 X NB1. IRS 55M14 is a yellows-resistant selection obtained from Dr. Henk Rietberg of the Instituut voor Rationele Suikerproductie, The Netherlands. In the 1964 yellows resistance evaluation test at Davis, California, C4742 ranked first in resistance among 17 inbred lined. C4742 has only fair resistance to bolting and curly top.

Suggested utilization: Use as a yellows-resistant breeding line. Not recommended for increase.

Item 2a. C413 Multigerm . . . . 8 pounds

This breeder seed is an increase of the 5th successive selection from US 75 for resistance to virus yellows. In the 1964 yellows resistance evaluation test at Davis, California, this selection showed a 14% yield loss from yellows, compared with a 37% loss for US 75. Hybrids involving C413 performed very well in early harvested 1964-65 yield tests in the Imperial Valley under essentially virus-yellows-free conditions.

Suggested utilization: a) Increase, and b) use as pollen parent in producing experimental quantities of hybrid seed.

Item 3. C5600 Multigerm . . . . 50 grams

A homozygous, diploid inbred produced by doubling the chromosomes in a haploid sugarbeet plant. The haploid was discovered during the examination of C_1 plants from the F_2b_7 generation of a cross between an annual beet and the multigerm NB1 inbred. C5600 is a curly top resistant annual inbred requiring a long photoperiod to induce bolting.

Suggested utilization: For use in studies requiring sugarbeet plants with a high degree of genetic uniformity. The U.S. Agricultural Research Station will make an increase of C5600 in 1966.

B. Developments in breeding and genetic research by Helen and V. F. Savitsky:

Item 4. S-63-9 Multigerm Tetraploid . . . . . . 100 grams

F_4 tetraploid derived from hybridization of tetraploid monogerm self-sterile line and tetraploid US 401. The line carries resistance to both curly top and leaf spot and is good in vigor and pollen production.

Suggested utilization: Pollinator for the production of triploid seed where resistance is required to both leaf spot and curly top.

Item 5. S-63-11 Multigerm Tetraploid . . . . 100 grams

Description and Suggested Utilization:
Same as for Item 4 (S-63-9).

Item 6. S-63-12 Multigerm Tetraploid . . . . 100 grams

Description and Suggested Utilization:

Same as for Item 4 (S-63-9).

Item 7. S-63-13 Multigerm Tetraploid . . . . 100 grams

Description and Suggested Utilization:
Same as for Item 4 (S-63-9).

II. Sugarbeet Investigations, Fort Collins, Colorado.

Developments in breeding research by J. O. Gaskill:

Item 8. FC 505 Monogerm . . . . 1/2 pound

Type O, rr, S_2 inbred line with high resistance to leaf spot and acceptable sucrose percent; combining ability not known; key strain no. SP 602063sl; derived from crosses between US 201 and type O monogerm lines.

Suggested utilization: Increase FC 505 and its male-sterile equivalent, FC 505-CMS. Also cross FC 505 with FC 502/2-CMS (e.g., by including a short row of FC 502/2-CMS in the planting of FC 505).

Item 9. FC 505-CMS Monogerm . . . . 1 pound

Male-sterile equivalent of FC 505, rr.

Suggested utilization: Increase, using FC 505 as pollinator.

III. Crops Research Laboratory, Logan, Utah

Developments in the breeding research of J. C. Theurer, G. K. Ryser, C. H. Smith, and E. H. Ottley:

Item 10. L 13 Monogerm . . . . 1 pound

An O-type line derived from SLC 129. Developed through interpollination of 3 plants with large roots that were much higher in sucrose percentage than the mean of the variety. The line is excellent in pollen production but has not been tested for combining ability.

Suggested utilization: Use as a substitute for SLC 129 in experimental hybrids.

IV. Plant Industry Station, Beltsville, Maryland.

Developments in breeding research by G. E. Coe:

Item 11. 65100-055 Monogerm . . . . 1 pound

An open-pollinated monogerm line with good resistance to leaf spot and acceptable tolerance to black root.

Suggested utilization: Seed production for further evaluation.

BEET SUGAR DEVELOPMENT FOUNDATION
P. O. BOX 538
FORT COLLINS, COLORADO
80521

UTILIZATION OF USDA SEED RELEASES, 1965

Item numbers and seed numbers are identical with those listed in the release memorandum dated June 3, 1965[1/]

I. U.S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane, B. L. Hammond, I. O. Skoyen, and R. J. Hecker.

Item 1. C4633 Monogerm

No increase will be made. The available quantity will be shared among Amalgamated, American Crystal, F & M, Great Western, Holly, Spreckels, Union, and Utah-Idaho.

Item 2. C4742 Multigerm

The utilization of this item will be the same as indicated in Item 1.

Item 3. C5600 Multigerm

The USDA will increase this item next spring at Medford or Salem from stecklings currently growing at Medford. Five grams of seed will be distributed at this time to American Crystal, F & M, Great Western, Holly, Spreckels, Union, and Utah-Idaho. Amalgamated will share in the increase.

B. Developments in breeding and genetic research by Helen and V. F. Savitsky.

Item 4. S-63-9 Multigerm tetraploid

Item 5. S-63-11 Multigerm tetraploid

Item 6. S-63-12 Multigerm tetraploid

Item 7. S-63-13 Multigerm tetraploid

The above items 4, 5, 6, and 7 will not be increased. The available quantity will be shared among Amalgamated, American Crystal, F & M, Great Western, Holly, Spreckels, Union, and Utah-Idaho.

1/ Memorandum to James H. Fischer from Dewey Stewart with the subject "Proposals for Seed Production and Utilization."

Utilization of USDA Seed Releases, 1965
Page 2

II. Sugarbeet Investigations, Fort Collins, Colorado

Developments in breeding research by J. O. Gaskill.

Item 8. FC 505 Monogerm

Item 9. FC 505-CMS Monogerm

The above Items 8 and 9 will be increased by the West Coast Beet Seed Company. The increase only will be shared by American Crystal, F & M, Great Western, Holly, Spreckels, and Union.

III. Crops Research Laboratory, Logan, Utah

Developments in the breeding research of J. C. Theurer, G. K. Ryser, C. H. Smith, and E. H. Ottley.

Item 10. L 13 Monogerm

No increase will be made. The available quantity will be distributed among the following companies: Amalgamated, American Crystal, F & M, Great Western, Holly, Spreckels, Union, and Utah-Idaho.

IV. Plant Industry Station, Beltsville, Maryland

Developments in breeding research by G. E. Coe.

Item 11. 65100-055 Monogerm

No increase will be made. The available quantity will be distributed as follows: 10 grams to Spreckels; the balance will be distributed among American Crystal, F & M, Great Western, Holly, and Utah-Idaho.

August 23, 1965
65-29
wmf

1965 Productions of 1964 Proposals for Seed Increase
(See 1964 Report, pp. 7-16)

1963 Item	Breeder Seed Description	1964 Production Pounds	1964 Production Designation
1	C3534 Monogerm	6	F65-534
2	C3534H4 Monogerm	6	F65-534HO
3	C321 Multigerm	0	
4	C3539T Multigerm	0	
5	101-7 Multigerm	0	
6	C057-15 Multigerm	0	
7	S-205 Tetraploid Multigerm	0	
8	S-206 Tetraploid Multigerm	0	
9	S-303 Tetraploid Monogerm	0	
10	FC 502/2 Monogerm	0	
11	FC 502/2-CMS Monogerm	0	
12	FC 504 Monogerm	0	
13	SP 6423-0 Monogerm	0	
14	SP 6423-01 Monogerm	0	
15	SP 6426-0 Monogerm	0	
16	SP 6426-01MS Monogerm	0	
17	SP 64194-0 Monogerm	0	
18	SP 6427-0 Multigerm	0	
19	SL 14500 Monogerm annual	Yes	Logan, Utah
20	SL 14500HO Monogerm annual	Yes	Logan, Utah

SUGARBEET SEED PRODUCTION IN UNITED STATES, 1955-1965[1/]

Year of production	100-pound bags Total	Multigerm	Monogerm	Percent monogerm
1955	114,187	114,152	35	Trace
1956	88,279	84,991	3,431	3.9
1957	94,547	83,812	10,735	11.4
1958	109,832	82,571	27,261	24.8
1959	111,788	83,594	28,194	25.2
1960	124,545	49,869	74,676	60.0
1961	95,541	25,227	70,314	73.6
1962	93,416	10,768	82,648	88.5
1963	94,447	12,487	81,960	86.8
1964	133,614	15,777	117,837	88.2
1965	93,363	671	92,692	99.3

1/ Production records from Agricultural Statistics.

PART II

DEVELOPMENT AND EVALUATION OF INBRED LINES AND HYBRID VARIETIES OF SUGARBEETS SUITABLE FOR CALIFORNIA

and

STUDIES ON POLYPLOIDY

J. S. McFarlane
B. L. Hammond
K. D. Beatty
I. O. Skoyen

Cooperation:

Holly Sugar Corporation
Spreckels Sugar Company
Union Sugar Division
Southwestern Irrigation Field Station

The research was supported in part by funds provided through the Beet Sugar Development Foundation (Projects 24 and 29).

REPORT ON FOUNDATION PROJECTS 24 AND 29

Summary of Accomplishments - 1965

PERFORMANCE OF MONOGERM HYBRID VARIETIES--Monogerm hybrids were included in 24 variety tests conducted throughout the beet-growing areas of California. A summary of the performance of ten hybrids expressed in percent of the performance of US H6 follows:

Hybrid	No. of tests			Gross sugar			Sucrose percentage		
	C	CV	Imp.	C	CV	Imp.	C	CV	Imp.
(562HO x 569) x 663	8	3	4	99	105	98	99	100	101
(562HO x 569) x NB7	7	5	7	100	90	108	98	98	106
(562HO x 569) x 413	4	0	1	111	---	109	100	---	100
(562HO x 569) x 430	5	2	1	103	105	97	99	101	100
(562HO x 546) x 264	7	3	2	105	107	108	98	100	101
(562HO x 546) x NB7	6	4	4	95	99	99	96	96	104
(563HO x 550) x 264	5	5	4	107	102	109	96	98	100
(563HO x 550) x NB7	6	2	4	94	97	95	95	101	103
(563HO x 534) x 264	5	5	4	103	107	105	100	101	103
(563HO x 546) x 264	4	3	0	103	110	---	98	101	---

C = Coastal valleys   CV = Central valley   Imp. = Imperial Valley

Greater differences were observed in hybrid performance in the three major production areas than have been observed in past years. This was particularly true with US H8, which has the parentage (562HO x 569) x NB7. In the 1965 tests this hybrid performed well in the coastal valleys and in the Imperial Valley but yielded an average ten percent less sugar per acre in five Central Valley tests than did US H6. In four 1964 Central Valley tests, US H8 yielded an average three percent more sugar per acre than did US H6. All three components of US H8 are inbred lines, and the variety responds more sharply to environmental differences than do top-cross hybrids involving the heterozygous pollen parents 663 and 264. The new hybrid, (563HO x 550) x 264, yielded well in all three areas but tended to be a little low in sucrose percentage, particularly in the coastal valleys. In addition to producing good root yields, this hybrid also showed very good bolting and curly top resistance. The hybrid, (563HO x 534) x 264, performed well in all areas and ranks high in bolting and curly-top resistance. The hybrid, (562 x 569) x C413, was included in five tests and performed very well in each test. C413 is a selection for yellows resistance from US 75. A small increase of C413 is being made in Oregon. (See page 8.)

BOLTING RESISTANCE--Bolting ranged from 0 to 100 percent in a November 20, 1964, planting at Salinas, California, A monogerm inbred designated 4806 and the multigerm inbred NB6 developed no seedstalks during the entire growing season. The monogerm inbreds 563, 550, and 534 also showed good resistance. The yellows-resistant selections, C413 and C430, were similar in resistance to the US 75 parental variety. Complete results of the November bolting resistance tests at Salinas and of an October test at Tracy are in Tables 1, 2, 3, and 4.

CURLY TOP RESISTANCE--Evaluations for curly top resistance were made in the field at Thatcher, Utah, and in the greenhouse at Salinas. Infection occurred late in the season at Thatcher and symptoms were mild. Improved resistance was observed in some of the newer test hybrids and parental lines. The male-sterile F_1 hybrid, 563HO x 534, showed the best resistance of any of the monogerm seed-bearing parents. The F_1 hybrid, 563HO x 550, also showed good resistance. Three-way hybrids involving these seed-bearing male steriles showed superior resistance to the commercial monogerm hybrids US H7 and US H8.

Progress has been made in developing a greenhouse method of selecting inbred lines with high curly top resistance. As pointed out in previous reports, little improvement has been made from mass selection in either self-sterile or self-fertile material. A technique introduced in 1964 involves saving seed from individual plants in segregating self-fertile populations. Eight plants of each segregate (four plants per six-inch pot) are then inoculated in the greenhouse. The average resistance rating of eight plants provides a more reliable measure of resistance than does individual plant ratings. Greenhouse progeny tests of selections made in 1964 show that progress can be made by this method. Seed increase of the most resistant selections will be made in 1966.

POLYPLOIDY--Dr. B. L. Hammond produced additional autotetraploids and F_1 hybrids between tetraploids. An attempt is being made to develop tetraploid pollen parents with high resistance to bolting and disease for use in the production of hybrid varieties. Dr. Hammond has also produced tetraploids of male-sterile equivalents of monogerm inbreds. The male sterility of the tetraploids is satisfactory, but difficulties have been experienced with pollen production in tetraploid monogerm inbreds.

Results with triploids in 1965 variety tests were not encouraging. Sucrose percentages tended to be low, and emergence problems were experienced under conditions of severe crusting. Seed germination of monogerm triploids tended to be low.

SEED LOTS MADE AVAILABLE THROUGH THE FOUNDATION--A monogerm inbred designated C4633 was made available in 1965. This type O inbred was selected from the second backcross to the multigerm NB1 inbred and combines resistance to bolting and curly top.

A homozygous, diploid inbred designated C5600 and produced by doubling the chromosomes in a haploid sugarbeet plant was also made available. The haploid was discovered by Dr. B. L. Hammond during the examination of C_1 plants from the F_2b_7 generation of a cross between an annual beet and the multigerm NB1 inbred. C5600 is a curly top resistant annual inbred requiring a long photo period to induce bolting.

A yellows-resistant selection from US 75 has been designated C413. This selection was made on the basis of freedom from yellowing and on root size. Five successive selections were made. Losses from yellows are approximately one-half as great in C413 as in US 75. Test hybrids utilizing C413 as the pollen parent have shown good yield, sucrose percentage, bolting resistance, and curly-top resistance.

A yellows-resistant inbred designated C4742 was selected from IRS 55M14 x NB1. IRS 55M14 is a yellows-resistant selection obtained from Dr. Henk Rietberg of the Instituut Voor Rationele Suikerproductie of The Netherlands. In the 1964 yellows-resistance evaluation test at Davis, California, C4742 ranked first in resistance among 17 inbred lines. C4742 has only fair resistance to bolting and curly top. (See page 8.)

Table 1. Percent bolting in sugarbeet three-way hybrids planted at Salinas, California, November 20, 1964.

Variety	Description	Date of Counting 6-23-65	7-21-65	8-27-65
		Percent	Percent	Percent
F64-425H11	(563HO x 550) x 3425	0.7	4	9
464H13	(563HO x 569) x 464	0.3	3	10
464H11	(563HO x 550) x 464	0.7	5	10
464H14	(563HO x 534) x 464	0.5	5	11
4404H8	(562HO x 546) x 4404	1.2	4	11
464H8	(562HO x 546) x 464	0.7	5	12
413H4	(562HO x 569) x 413	0.7	7	12
263TH2	(MS of NB1 x NB5) x 663 Tetra	2.9	6	12
F64-425H4	(562HO x 569) x 3425	1.5	5	12
464H12	(563HO x 546) x 464	0.9	5	13
F64-425H8	(562HO x 546) x 3425	1.5	6	13
413H8	(562HO x 546) x 413	0.9	7	14
F63-64H4	(562HO x 569) x 264	1.4	7	15
F64-30H8	(562HO x 546) x F64-30	1.1	8	16
F64-30H4	(562HO x 569) x F64-30	2.0	9	17
437H8	(562HO x 546) x 437	1.2	8	18
4539H12	(563HO x 546) x NB7	0.9	7	19
F63-64H2	(MS of NB1 x NB5) x 264	3.3	11	22
463H4	(562HO x 569) x 663	3.0	12	22
4539H8	(562HO x 546) x NB7	1.1	12	22
4539H9	(562HO x 549) x NB7	2.5	13	25
4539H11	(563HO x 550) x NB7	3.8	14	26
437H4	(562HO x 569) x 437	4.6	14	26
463TH4	(562HO x 569) x 663 Tetra	2.8	15	27
463H2	(MS of NB1 x NB5) x 663	2.7	15	29
4539H4	(562HO x 569) x NB7	1.9	14	30
472H4	(562HO x 569) x 472	8.7	25	42
	L.S.D. (5%)	-	6.0	8.7

Table 2. Percent bolting in sugarbeet single-cross hybrids and open-pollinated lines planted at Salinas, California, November 20, 1964.

Variety	Description	Date of Counting 6-23-65	7-21-65	8-27-65
		Percent	Percent	Percent
Single-cross hybrids				
4640H4	563HO x 4640	0.5	3	7
F60-512H1	MS of NB5 x NB6	0.7	2	7
F64-550H4	563HO x 550	0.3	4	10
F64-546H3	562HO x 546	3.6	7	11
4757H3	562HO x 4757	1.4	9	15
F64-569H3	562HO x 569	2.1	10	15
3534H4	563HO x 534	2.0	7	15
4754H3	562HO x 4754	1.3	7	18
4753H3	562HO x 4753	1.7	10	18
4522H3	562HO x 4522	2.4	9	18
1547H1	MS of NB1 x NB5	0.2	5	19
4716H3	562HO x 4716-18	2.9	12	23
4569H4	563HO x 569	2.4	14	27
F64-648H3	562HO x 648	7.7	28	37
4683H3	562HO x 4683	14.2	35	51
F64-649H3	562HO x 649	12.9	44	58
4564H4	563HO x 4564	40.4	76	83
	L.S.D. (5%)	-	6.0	8.7
Open-pollinated lines				
F64-425	663 Tetra x 8539 Tetra	0.4	2	4
F64-63T	Tetra 663	0.6	3	7
413C	YRS US 75	1.1	6	13
234	Rietberg YRS	1.6	4	14
663	(US15 x US22/3) Sel.	2.7	8	14
430B	YRS US 75	2.6	8	15
F64-30	YRS US 75	2.3	9	16
F63-64	Bolt. res. 663	1.3	7	18
F57-68	US 75	4.3	10	19
437B	YRS 663	1.9	11	22
4404B	NB1 Tetra x 8539 Tetra	0.9	19	45
472	Inc. 9151 x 9931	15.4	39	55
	L.S.D. (5%)	-	6.0	8.7

Table 3. Percent bolting in sugarbeet inbreds planted at Salinas, California, November 20, 1964.

Inbred	Description	Date of Counting 6-23-65	7-21-65	8-27-65
		Percent	Percent	Percent
4806	mm inbred	0	0	0
F60-512	NB6	0	0	0
4664-3	mm inbred	0	0	1
4664-5	mm inbred	1	2	4
4640	mm inbred	2	4	7
1547	NB5	1	2	12
F64-550	mm inbred	1	10	14
F63-563	mm inbred	1	7	15
F64-550HO	MS of 550	1	7	16
F58-554	NB4	2	9	16
4757B	Yellows res. inbred	5	12	18
F64-562	mm inbred	5	11	19
F63-563HO	MS of 563	1	12	19
3534	mm inbred	4	12	19
4754B	Yellows res. inbred	2	11	21
3539T	NB7 (tetra)	7	14	23
0539	NB7	1	14	26
F63-546	mm inbred	5	20	28
4753C	Yellows res. inbred	8	24	28
F64-562HO	MS of 562	3	14	30
3716-18	Yellows res. inbred	14	24	34
F64-569	mm inbred	5	26	35
F64-648	mm inbred	15	33	38
4522	mm inbred	12	35	42
4683-1	mm inbred	14	33	43
F56-502	NB1	14	43	55
F64-649	mm inbred	12	51	61
4569	mm inbred	20	49	62
F58-502HO	MS of NB1	15	44	63
4683-7	mm inbred	33	62	73
4683-5	mm inbred	58	81	92
4564-1	mm inbred	70	95	100
	L.S.D. (5%)	-	9.7	11.0

Table 4. Percent bolting in sugarbeet hybrids, open-pollinated lines, and inbreds in an October 14, 1964, planting at Tracy, California.

Variety	Description	Bolting Percent
Hybrids and open-pollinated lines		
F63-549H3	562HO x 549	1
F59-512H1	MS of NB5 x NB6	1
3550H4	563HO x 550	2
3534H4	563HO x 534	3
F63-546H4	563HO x 546	3
3425T	663 Tetra x NB7 Tetra	4
F64-30H4	(562HO x 569) x F64-30	4
F64-425H4	(562HO x 569) x 3425	4
2539H4	(562HO x 569) x NB7	6
1547H1	MS of NB1 x NB5	6
263TH4	(562HO x 569) x 663T	7
413H4	(562HO x 569) x 413	7
464H14	(563HO x 534) x 464	8
F64-569H3	562HO x 569	8
F57-68	US 75	10
4539H11	(563HO x 550) x NB7	10
F62-63T	663 Tetra	10
3539H7	(569HO x 563) x NB7	11
F63-546H3	562HO x 546	12
464H11	(563HO x 550) x 464	13
363H7	(569HO x 563) x 663	13
F64-30	YRS US 75	14
363H4	(562HO x 569) x 663	15
3539H8	(562HO x 546) x NB7	16
464H8	(562HO x 546) x 464	17
163H2	US H6	19
F64-30H8	(562HO x 546) x F64-30	19
363H8	(562HO x 546) x 663	20
F63-64	Bolt. res. 663	21
437H4	(562HO x 569) x 437	21
F59-509H1	MS of NB1 x NB3	22
F57-63	Inc. 663	24
F63-648H3	562HO x 648	26
263H1	US H2	33
Inbreds		
F59-512	NB6	0
4503	Mild. res. inbred	0
F56-502	NB1	3
F61-562	mm inbred	4
3550	mm inbred	4
F63-549	mm inbred	5
1547	NB5	5
F61-562HO	MS of 562	6
F62-546	mm inbred	7
0539	NB7	9
F58-502HO	MS of NB1	11

SUMMARY.--Gross sugar yields of bolting-resistant hybrids in 1965 California variety tests, expressed in percent of the yield of US H6.

Location	Testing Agency	US H6	63H4	64H8	64H11	64H12	64H14	539H4	539H7	539H8	539H11	13H4	30H4	425H4
Coastal Area														
Salinas - Nov. plt.	USDA	100	97	110	103	107	90	96	-	94	95	104	106	86
Salinas - Dec. plt.	"	100	95	98	103	103	95	92	-	91	91	110	100	94
King City	Union	100	95	109	104	99	103	95	-	97	81	116	99	100
San Lucas	"	100	97	111	112	-	104	102	-	-	95	114	107	103
Betteravia	"	100	108	109	114	-	125	91	-	-	98	-	103	-
Spreckels - Test 1	Spreckels	100	106	98	-	-	-	117	-	107	106	-	-	-
Spreckels - Test 2	"	100	102	101	-	102	-	108	-	100	-	-	-	-
San Ardo	"	100	92	-	-	-	-	-	-	83	-	-	-	-
Central Valley														
Arvin	"	100	107	102	106	110	113	99	-	93	92	-	-	-
Kettleman	"	100	-	110	102	106	-	-	-	-	-	-	-	-
Goshen	"	100	101	-	-	-	108	90	-	116	-	-	-	-
Del Paso	"	100	106	110	99	114	102	87	-	91	-	-	-	106
Le Grand	Holly	100	-	-	96	-	106	88	-	-	-	-	100	100
Tulare	"	100	-	-	109	-	108	-	-	97	101	-	109	106
Tracy	"	100	-	-	-	-	-	85	-	-	-	-	-	-
Imperial Valley														
Brawley - Early	USDA	100	93	110	102	-	98	96	90	97	88	109	97	95
Brawley - Late	"	100	93	106	107	-	103	101	94	93	-	-	-	-
El Centro	Union	100	103	-	114	-	104	102	97	101	-	-	-	-
Imp. Valley	Holly	100	102	-	111	-	114	119	106	103	-	-	-	-
Imp. Valley - 1st har.	"	100	-	-	-	-	-	118	107	-	103	-	-	-
" " - 2nd "	"	100	-	-	-	-	-	109	100	-	96	-	-	-
" " - 3rd "	"	100	-	-	-	-	-	113	103	-	91	-	-	-

Description of hybrids:

63H4----(562H0 x 569) x 663
64H8----(562H0 x 546) x 264
64H11---(563H0 x 550) x 264
64H12---(563H0 x 546) x 264
64H14---(563H0 x 534) x 264
539H4---(562H0 x 569) x NB7

539H7---(563H0 x 569) x NB7
539H8---(562H0 x 546) x NB7
539H11--(563H0 x 550) x NB7
13H4----(562H0 x 569) x 413
30H4----(562H0 x 569) x 330
425H4---(562H0 x 569) x 3425

264 = Bolt. res. sel. 663

SUMMARY.--Sucrose percentage of bolting-resistant hybrids in 1965 California variety tests, expressed in percent of US H6.

Location	Testing Agency	US H6	63H4	64H8	64H11	64H12	64H14	539H4	539H7	539H8	539H11	13H4	30H4	425H4
Coastal Area														
Salinas - Nov. plt.	USDA	100	105	103	96	102	99	104	-	103	99	100	100	95
Salinas - Dec. plt.	"	100	99	99	97	98	101	96	-	101	97	96	99	99
King City	Union	100	102	100	96	97	104	93	-	88	89	103	98	93
San Lucas	"	100	96	99	98	-	98	97	-	-	94	99	99	99
Betteravia	"	100	99	96	95	-	100	93	-	-	93	-	97	-
Spreckels - Test 1	Spreckels	100	98	93	-	-	-	108	-	92	95	-	-	-
Spreckels - Test 2	"	100	95	96	-	96	-	97	-	94	-	-	-	-
San Ardo	"	100	98	-	-	-	-	-	-	95	-	-	-	-
Central Valley														
Arvin	"	100	103	98	98	100	103	100	-	97	99	-	-	-
Kettleman	"	100	-	103	100	103	-	-	-	-	-	-	-	-
Goshen	"	100	97	-	-	-	100	98	-	94	-	-	-	-
Del Paso	"	100	100	100	96	99	95	100	-	94	-	-	-	95
Le Grand	Holly	100	-	-	97	-	101	93	-	-	-	-	98	101
Tulare	"	100	-	-	99	-	104	-	-	100	103	-	104	96
Tracy	"	100	-	-	-	-	-	99	-	-	-	-	-	-
Imperial Valley														
Brawley - Early	USDA	100	99	100	99	-	102	102	101	103	105	100	100	101
Brawley - Late	"	100	102	102	102	-	103	106	104	106	-	-	-	-
El Centro	Union	100	101	-	99	-	101	103	100	103	-	-	-	-
Imp. Valley	Holly	100	102	-	98	-	104	106	102	103	-	-	-	-
Imp. Valley - 1st har.	"	100	-	-	-	-	-	109	104	-	102	-	-	-
" " - 2nd "	"	100	-	-	-	-	-	105	103	-	102	-	-	-
" " - 3rd "	"	100	-	-	-	-	-	109	104	-	103	-	-	-

VARIETY TESTS, SALINAS, CALIFORNIA, 1965

Location: Spence Field of the U. S. Agricultural Research Station.

Soil type: Sandy loam.

Previous crops: Fallow, 1962 and 1963; vetch cover crop, 1964.

Fertilizer used: 900 lbs. per acre 10-10-5 preplant.
250 lbs. per acre ammonium sulfate sidedressed February 26, 1965.
275 lbs. per acre ammonium sulfate sidedressed May 7, 1965.

Planting date: Bolting test, November 19, 1964.
Yield tests, December 16, 1964.

Thinning date: Bolting test, January 19-20, 1965.
Yield tests, February 4, 1965.

Harvest date: Bolting test, September 13-16, 1965.
Yield tests, September 16-22, 1965.

Irrigations: Sprinkler irrigation as required up to May 10, 1965. Subsequently, furrow irrigation used at about ten-day intervals.

Diseases and insects: Infection with yellows viruses was approaching 100 percent by mid June. Test plots sprayed on March 1, 1965 with Meta Systox R plus DDT for control of green peach aphid and cutworm at rate of one and one-half pints per acre Meta Systox R and two lbs., actual, of DDT. Plots sprayed a second time on March 25, with Meta Systox R for control of green peach aphid.

Experimental design: Bolting test planted in a 7 x 8 rectangular lattice design with four replications and analyzed as a randomized block. Varieties planted in single-row plots; plots 68 feet long. One yield test planted in a 4 x 5 rectangular lattice repeated to give ten replications. A second yield test planted in a randomized block with five replications. Varieties planted in single-row plots; plots 110 feet long. Row spacing 28 inches wide.

Sugar analysis: From two samples per plot, of approximately ten roots each, at the sugar analytical laboratory, United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1965

(4 replications of each variety)

Planted: November 19, 1964
Harvested: September 13-16, 1965

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
413H8	(562HO x 546) x 413	10,880	35.15	15.5	14.2	168
F64-30H8	(562HO x 546) x F64-30	10,540	33.27	15.9	15.8	162
4716H3	562HO x 4716-18	10,020	31.46	16.0	22.6	175
234	Rietberg YRS	9,900	30.71	16.2	14.0	140
464H8	(562HO x 546) x 464	9,820	31.01	15.9	11.5	154
F64-30	YRS US75	9,700	33.33	14.6	16.2	169
464H12	(563HO x 546) x 464	9,580	30.66	15.7	12.5	159
F64-30H4	(562HO x 569) x F64-30	9,520	31.12	15.4	17.1	163
413C	YRS US75	9,420	28.19	16.7	12.6	163
413H4	(562HO x 569) x 413	9,340	30.69	15.4	12.4	161
464H13	(563HO x 569) x 464	9,300	29.15	15.9	9.8	161
263TH2	(MS of NB1 x NB5) x 663 Tetra	9,240	29.02	16.1	11.5	134
F63-64H2	(MS of NB1 x NB5) x 264	9,240	28.51	16.3	21.7	157
464H11	(563HO x 550) x 464	9,240	31.28	14.8	9.9	172
4757H3	562HO x 4757	9,060	28.70	15.7	15.0	180
4539H12	(563HO x 546) x NB7	9,040	29.36	15.4	18.5	164
4754H3	(562HO x 569) x 4754	9,040	29.44	15.4	18.3	161
463H2	(MS of NB1 x NB5) x 663	8,960	29.30	15.4	29.3	170
437H8	(562HO x 546) x 437	8,800	29.81	14.9	18.2	168
F63-64H4	(562HO x 569) x 264	8,760	29.01	15.1	14.5	170
F64-425H11	(563HO x 550) x 3425	8,760	29.25	15.1	9.0	162
430B	YRS US75	8,740	30.84	14.6	15.2	188
463H4	(562HO x 569) x 663	8,680	26.83	16.1	21.9	186
4539H4	(562HO x 569) x NB7	8,560	26.71	16.0	29.5	178
4539H11	(563HO x 550) x NB7	8,520	27.90	15.3	25.7	151
F64-425H8	(562HO x 546) x 3425	8,500	28.74	14.8	13.0	168
4569H4	563HO x 569	8,420	25.72	16.9	26.8	172
4539H8	(562HO x 546) x NB7	8,380	26.61	15.8	22.1	167
4753H3	562HO x 4753	8,320	25.30	16.5	18.3	177
4539H9	(562HO x 549) x NB7	8,280	28.84	14.5	25.1	162
F64-63T	Tetra 663	8,260	28.48	14.5	6.9	133
463TH4	(562HO x 569) x 663 Tetra	8,200	28.88	14.1	27.0	154
464H14	(563HO x 534) x 464	8,100	26.57	15.3	11.0	157
F57-68	US 75	7,960	27.86	14.4	18.8	159
437H4	(562HO x 569) x 437	7,940	26.37	15.1	25.7	175
F63-64	Bolt. res. 663	7,860	28.22	14.0	17.8	165
437B	YRS 663	7,840	28.10	14.0	22.0	158
4640H4	563HO x 4640	7,840	24.21	16.3	7.2	166
F64-550H4	563HO x 550	7,800	24.70	15.7	9.7	142
F60-512H1	MS of NB5 x NB6	7,780	27.26	14.4	7.2	161

(Continued on next page)

VARIETY TEST, SALINAS, CALIFORNIA, 1965 continued

Planted: November 19, 1964
Harvested: September 13-16, 1965

(4 replications of each variety)

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
F64-425H4	(562HO x 569) x 3425	7,720	26.37	14.6	12.3	172
F64-546H3	562HO x 546	7,320	23.34	15.8	11.0	177
1547H1	MS of NB1 x NB5	7,300	22.25	16.4	19.1	147
4404H8	(562HO x 546) x 4404	7,120	23.48	15.2	11.4	152
4683H3	562HO x 4683	6,900	22.08	15.8	50.6	165
472H4	(562HO x 569) x 472	6,860	20.39	16.7	41.9	153
663	(US15 x US22/3) Sel.	6,820	22.74	15.1	14.4	146
F64-649H3	562HO x 649	6,540	20.86	15.7	57.5	164
F64-425	663 Tetra x 8539 Tetra	6,360	21.78	14.6	3.5	132
F64-569H3	562HO x 569	6,340	18.69	16.8	15.4	170
F64-648H3	562HO x 648	6,200	18.31	16.8	37.3	164
4564H4	563HO x 4564	6,100	21.55	14.2	82.7	160
4522H3	562HO x 4522	5,940	18.51	16.2	18.2	167
472	Inc. 9151 x 9931	4,900	16.22	15.0	55.1	149
3534H4	563HO x 534	4,760	14.65	16.3	14.5	146
4404B	NB1 Tetra x 8539 Tetra	4,640	16.22	14.2	44.7	128
General MEAN of all varieties		8,140	26.50	15.5	20.8	Beets
S. E. of MEAN		547	2.09	0.58	3.10	per
Significant Difference (19:1)		1,532	5.86	1.62	8.67	100'
Coefficient of Variation (%)		13.45	15.79	7.47	29.77	row

Odds 19:1 = 1.976 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar 1/	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	55	1.94	85.34	2.52	829.46
Between replications	3	3.30	64.65	11.01	9.23
Remainder (Error)	165	0.30	17.51	1.33	38.33
Total	223				
Calculated F value		6.49**	4.88**	1.90**	21.64**

** Exceeds the 1% point of significance (F=1.60)

1/ Mean squares for gross sugar computed on basis of tons sugar per acre.

VARIETY TEST, SALINAS, CALIFORNIA, 1965

(5 replications of each variety)

Planted: December 16, 1964
Harvested: September 21, 1965

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
463H2	(MS of NB1 x NB5) x 663	10,940	36.22	15.1	12.2	140
234	Rietberg YRS	10,920	33.46	16.4	6.2	100
413C	YRS US75	10,860	33.77	16.2	3.1	134
F63-64H2	(MS of NB1 x NB5) x 264	10,720	34.14	15.7	7.5	135
F64-30	YRS US75	10,520	35.46	14.9	6.1	149
F64-425H8	(562HO x 569) x 3425	10,480	33.41	15.7	4.3	130
4539H8	(562HO x 546) x NB7	10,000	32.90	15.3	12.3	137
464H13	(563HO x 569) x 464	9,860	31.56	15.7	3.7	115
3616H2	(MS of NB1 x NB5) x 3616	9,840	31.10	16.1	2.5	114
063H3	(MS of NB1 x NB4) x 663	9,660	32.26	15.0	12.7	132
4539H12	(563HO x 546) x NB7	9,620	31.80	15.2	12.0	115
4539H9	(562HO x 549) x NB7	9,400	32.12	14.7	18.5	131
437B	YRS 663	8,820	29.28	15.1	4.9	134
122RS-C	2nd YRS US75 (Fife)	8,800	30.25	14.6	24.3	131
321	YRS 671	8,400	29.11	14.5	24.4	133
384H7	(569HO x 563) x 384	8,380	27.13	15.5	15.7	127
413DS-23	1st YRS US75 (Fife)	7,380	24.44	15.2	6.3	140
F57-68	US 75	7,360	24.31	15.1	8.0	107
472	Inc. 9151 x 9931	7,080	22.85	15.6	31.1	130
663	(US15 x US22/3) sel.	6,920	22.93	15.1	6.2	86
General MEAN of all varieties		9,300	30.43	15.3	11.1	Beets
S. E. of MEAN		382	1.59	0.35	1.4	per
Significant Difference (19:1)		1,074	4.47	0.99	4.0	100'
Coefficient of Variation (%)		9.18	11.67	5.13	28.6	row

Odds 19:1 = 1.99 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar 1/	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	19	2.24	83.89	1.32	323.46
Between replications	4	3.43	140.59	4.58	44.65
Remainder (Error)	76	0.18	12.61	0.62	10.08
Total	99				
Calculated F value		12.32**	6.65**	2.15**	32.10**

** Exceeds the 1% point of significance (F=2.13)

1/ Mean squares for gross sugar computed on basis of tons sugar per acre.

VARIETY TEST, SALINAS, CALIFORNIA, 1965

(10 replications of each variety)

Planted: December 16, 1964
Harvested: September 17-20, 1965

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
413H4	(562HO x 569) x 413	11,640	38.07	15.3	4.8	137
413H8	(562HO x 546) x 413	11,580	36.22	16.1	5.0	133
464H12	(563HO x 546) x 464	10,960	35.07	15.6	4.3	133
464H11	(563HO x 550) x 464	10,900	35.52	15.4	3.8	133
F64-30H8	(562HO x 546) x F64-30	10,800	33.82	16.0	5.9	130
463H2	(MS of NB1 x NB5) x 663	10,600	33.49	15.9	13.7	138
F64-30H4	(562HO x 569) x F64-30	10,560	33.76	15.7	4.4	137
464H8	(562HO x 546) x 464	10,420	33.08	15.8	3.7	127
437H4	(562HO x 569) x 437	10,160	32.45	15.7	12.3	125
437H8	(562HO x 546) x 437	10,140	31.94	15.9	10.5	134
463H4	(562HO x 569) x 663	10,060	32.18	15.7	10.7	144
464H14	(563HO x 534) x 464	10,040	31.53	16.0	3.9	127
F64-425H4	(562HO x 569) x 3425	10,000	32.06	15.7	5.2	127
4539H4	(562HO x 569) x NB7	9,760	32.18	15.2	16.7	131
4539H11	(563HO x 550) x NB7	9,680	31.61	15.4	14.0	130
F64-425H11	(563HO x 550) x 3425	9,500	30.70	15.6	3.4	119
263TH4	(562HO x 569) x 663 Tetra	9,420	30.74	15.4	3.7	101
263TH2	(MS of NB1 x NB5) x 663 Tetra	9,240	31.46	14.7	6.8	70
4404H8	(562HO x 546) x 4404	8,940	28.54	15.7	10.6	123
472H4	(562HO x 569) x 472	8,500	26.09	16.4	24.8	137
General MEAN of all varieties		10,140	32.53	15.7	8.4	Beets
S. E. of MEAN		335	1.30	0.32	0.84	per
Significant Difference (19:1)		940	3.65	N.S.	2.34	100'
Coefficient of Variation (%)		10.45	12.66	6.57	31.45	row

Odds 19:1 = 1.976 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	Mean Squares: Gross Sugar[1]	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	19	1.67	69.46	1.33	324.30
Between replications	9	0.49	17.00	1.74	10.77
Remainder (Error)	171	0.28	16.96	1.06	6.99
Total	199				
Calculated F value		5.94**	4.10**	N.S.	46.40**

** Exceeds the 1% point of significance (F=2.02)

[1] Mean squares for gross sugar computed on basis of tons sugar per acre.

VARIETY TEST, KING CITY, CALIFORNIA, 1965

Grower and location: A. S. Duarte, King City, California.

Soil type: Sandy loam.

Previous crops: Onions, 1962; peas and lettuce, 1963; lettuce, 2 crops, 1964.

Fertilizer used: 300 lbs. per acre 16:20:00, preplant.
700 lbs. per acre ammonium sulfate applied in two sidedress applications.

Planting date: February 16, 1965.

Thinning date: March 26, 1965.

Harvest date: November 3-4, 1965.

Irrigations: Six.

Diseases and insects: Moderate infections of yellows viruses, and the mosaic virus, as well as light rust, occurred in field where test plot was located. Leaf miner caused some damage in the field. Light infestations of root aphid and nematode existed in the test plot area.

Experimental design: Randomized block design used for two tests; test 1 with eight replications and test 2 with four replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Betteravia, California.

Remarks: Seed was furnished, test designed, and results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, KING CITY, CALIFORNIA, 1965

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent
413H4	(562HO x 569) x 413	6,900	24.67	14.0
464H8	(562HO x 546) x 464	6,490	23.95	13.6
F64-30H8	(562HO x 546) x F64-30	6,450	23.96	13.5
263TH4	(562HO x 569) x 663 Tetra	6,280	23.46	13.4
464H11	(563HO x 550) x 464	6,180	23.70	13.1
464H14	(563HO x 534) x 464	6,140	21.72	14.2
F64-425H4	(562HO x 569) x 3425	5,940	23.44	12.7
463H2	(MS of NB1 x NB5) x 663	5,940	21.83	13.6
F64-30H4	(562HO x 569) x F64-30	5,860	22.15	13.3
463H4	(562HO x 569) x 663	5,670	20.38	13.9
4539H4	(562HO x 569) x NB7	5,670	22.46	12.6
4539H11	(563HO x 550) x NB7	4,810	20.02	12.1
General MEAN of all varieties		6,027	22.64	13.3
S. E. of MEAN		272	0.78	0.29
Significant Difference (19:1)		766	2.20	0.80
Coefficient of Variation (%)		12.77	9.77	6.05

Odds 19:1 = 1.99 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Between varieties	11	2,210,839	17.32	3.06
Between replications	7	1,910,495	49.77	7.94
Remainder (Error)	77	592,790	4.90	0.65
Total	95			
Calculated F value		3.73**	3.53**	4.71**

** Exceeds the 1% point of significance (F=2.48)

VARIETY TEST, KING CITY, CALIFORNIA, 1965

(4 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent
413H8	(562HO x 546) x 413	7,620	28.41	13.5
263TH2	(MS of NB1 x NB5) x 663 Tetra	6,880	28.81	12.0
437H8	(562HO x 546) x 437	6,070	24.87	12.3
463H2	(MS of NB1 x NB5) x 663	6,030	21.98	13.9
464H12	(563HO x 546) x 464	5,990	22.22	13.5
4539H12	(563HO x 546) x NB7	5,890	24.48	12.0
4539H8	(562HO x 546) x NB7	5,830	23.78	12.3
F64-425H8	(562HO x 546) x 3425	5,720	23.13	12.3
437H4	(562HO x 569) x 437	5,410	20.86	13.0
4404H8	(562HO x 546) x 4404	5,260	19.95	13.2
4539H9	(562HO x 549) x NB7	4,960	21.24	11.7
472H4	(562HO x 569) x 472	4,220	15.46	13.6
General MEAN of all varieties		5,830	22.93	12.8
S. E. of MEAN		459	1.89	0.41
Significant Difference (19:1)		1,318	5.44	1.17
Coefficient of Variation (%)		15.76	16.52	6.37

Odds 19:1 = 2.03 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	11	3,018,754	52.64	2.23
Between replications	3	3,899,764	40.26	1.67
Remainder (Error)	33	842,782	14.35	0.66
Total	47			
Calculated F value		3.58**	3.67**	3.38**

** Exceeds the 1% point of significance (F=2.82)

VARIETY TEST, SAN LUCAS, CALIFORNIA, 1965

Grower and location: Mesa Farms No. 2, San Lucas, California.

Soil type: Salinas clay loam.

Previous crops: Dry land barley, 1962; sugarbeets, 1963; tomatoes, 1964.

Fertilizer used: 400 lbs. per acre 15:08:00, preplant.
500 lbs. per acre 20% Aqua, sidedressed.
400 lbs. per acre 20% Aqua, applied in two applications through sprinkler irrigation system.

Planting date: February 23, 1965.

Thinning date: April 15, 1965.

Harvest date: October 26, 1965.

Irrigations: Eleven.

Diseases and insects: Moderate infections with yellows viruses and Cercospora leaf spot occurred in field where test was located. Leaf miner also caused some damage.

Experimental design: Twelve varieties in a randomized block design with eight replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Betteravia, California.

Remarks: Seed was furnished, test designed, and results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SAN LUCAS, CALIFORNIA, 1965

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Thin Juice Purity Percent	Harvest Count Number
413H4	(562HO x 569) x 413	9,580	28.13	17.0	89.5	149
464H11	(563HO x 550) x 464	9,470	28.26	16.8	90.8	134
F64-30H8	(562HO x 546) x F64-30	9,350	27.29	17.1	90.8	142
464H8	(562HO x 546) x 464	9,340	27.51	17.0	92.1	147
263TH4	(562HO x 569) x 663 Tetra	9,040	27.00	16.8	91.0	134
F64-30H4	(562HO x 569) x F64-30	8,970	26.51	16.9	90.9	151
464H14	(563HO x 534) x 464	8,760	26.08	16.8	90.9	143
F64-425H4	(562HO x 569) x 3425	8,670	25.59	16.9	91.8	142
4539H4	(562HO x 569) x NB7	8,630	25.92	16.6	91.7	144
463H2	(MS of NB1 x NB5) x 663	8,420	24.61	17.1	91.2	141
463H4	(562HO x 569) x 663	8,160	24.84	16.4	91.4	143
4539H11	(563HO x 550) x NB7	8,040	25.08	16.0	91.5	151
General MEAN of all varieties		8,868	26.40	16.8	91.1	Beets
S. E. of MEAN		243	0.65	0.14	0.54	per
Significant Difference (19:1)		684	1.84	0.40	N.S.	100'
Coefficient of Variation (%)		7.75	6.99	2.42	1.68	row

Odds 19:1 = 1.99 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose	Percent Purity
Between varieties	11	2,093,816	12.53	0.80	3.55
Between replications	7	1,808,783	17.13	0.84	4.60
Remainder (Error)	77	472,080	3.41	0.17	2.35
Total	95				
Calculated F value		4.44**	3.67**	4.85**	N.S.

** Exceeds the 1% point of significance (F=2.48)

VARIETY TEST, BETTERAVIA, CALIFORNIA, 1965

Grower and location: R. N. Winters, Guadalupe, California.

Soil type: Sandy loam.

Previous crops: Beans, 1962 and 1963; potatoes, 1964.

Fertilizer used: 500 lbs. per acre NH_3, preplant.
80 lbs. actual N, applied as NH_3, per acre sidedressed.

Planting date: February 5, 1965.

Thinning date: March 31, 1965.

Harvest date: October 28, 1965.

Irrigations: Four.

Diseases and insects: Not a factor in the test plot.

Experimental design: Eight varieties planted in an 8 x 8 latin square design, and results analyzed as a randomized block. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Betteravia, California.

Remarks: Seed was furnished, test designed, and results analyzed by United States Agricultural Research Station, Salinas, California.

VARIETY TEST, BETTERAVIA, CALIFORNIA, 1965

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
464H14	(563HO x 534) x 464	8,580	29.04	14.8	135
464H11	(563HO x 550) x 464	7,870	27.87	14.1	137
464H8	(562HO x 546) x 464	7,520	26.45	14.2	136
463H4	(562HO x 569) x 663	7,410	25.14	14.7	117
F64-30H4	(562HO x 569) x F64-30	7,120	24.83	14.4	134
463H2	(MS of NB1 x NB5) x 663	6,890	23.34	14.8	143
4539H11	(563HO x 550) x NB7	6,770	24.67	13.7	145
4539H4	(562HO x 569) x NB7	6,270	22.89	13.7	125
General MEAN of all varieties		7,300	25.53	14.3	Beets
S. E. of MEAN		252	0.81	0.15	per
Significant Difference (19:1)		714	2.30	0.44	100'
Coefficient of Variation (%)		9.75	8.99	3.05	row

Odds 19:1 = 2.0 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	7	4,063,690	36.34	1.54
Between replications	7	347,848	7.34	0.63
Remainder (Error)	49	506,380	5.27	0.19
Total	63			
Calculated F value		8.02**	6.90**	8.11**

** Exceeds the 1% point of significance (F=3.02)

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1965

TEST AREAS:	S P R E C K E L S			S P R E C K E L S			G R E E N F I E L D			S A N A R D O			G I L R O Y		
Variety	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
US H8	3.443	25.86	13.3	3.000	23.11	13.0	3.643	24.50	14.9				3.949	24.51	16.1
4539H12	3.394	27.40	12.4	2.934	22.54	13.0									
263TH4	3.330	26.28	12.7												
US H7	3.138	24.19	13.0	2.843	22.39	12.7	3.582	24.56	14.6	4.184	28.08	14.9	3.850	24.15	16.0
4539H8	3.145	25.81	12.2	2.793	22.20	12.6				3.765	26.10	14.5			
4539H1	3.145	24.86	12.7												
4539H11	3.117	24.94	12.5												
US H6	2.948	22.46	13.2	2.788	20.76	13.4				4.530	29.84	15.2			
463H8	2.882	23.54	12.3	2.812	21.86	12.9									
463H12				2.840	22.17	12.8									
F63-549H3				2.089	15.89	13.2									
464H4	3.218	24.71	13.0												
GENERAL MEAN	3.105	24.57	12.6	2.745	21.25	12.9	3.606	24.34	14.8	4.102	27.86	14.8	3.904	24.33	16.1
LSD @ P = .05	0.356	2.30	0.86	0.314	2.24	0.55	N.S.	N.S.	N.S.	0.597	3.86	0.57	0.420	N.S.	0.52
LSD @ P = .01	0.473	3.06	N.S.	0.417	2.96	N.S.	N.S.	N.S.	N.S.	0.792	5.11	0.76	0.557	N.S.	0.69
S E of Mean	0.126	0.819	0.303	0.111	0.794	0.195	0.158	1.120	0.264	0.212	1.333	0.203	0.148	0.947	0.185
S E % of Mean	4.06	3.33	2.40	4.04	3.74	1.50	4.38	4.58	1.80	5.17	4.78	7.58	3.79	3.89	1.10
No. Var. in Test		12			12			10			12			12	
Planting Date		12-9-64			1-15-65			1-20-65			1-27-65			2-25-65	
Harvest Date		8-18-65			9-3-65			10-8-65			10-1-65			9-14-65	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1965

TEST AREAS:	ARVIN			KETTLEMAN CITY			STRATFORD			GOSHEN		
	HUTIBERG			D'ARTINEY			VIEIRA			GOEMAN		
Variety	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
3539H1							2.450	14.8	16.4			
464H-14	4.869	39.1	12.5							3.164	22.2	14.3
463H-12	4.735	39.2	12.1	4.444	38.1	11.6						
263TH-4	4.678	41.1	11.4							3.201	22.9	14.1
US H7	4.595	36.7	12.5							2.948	21.4	13.9
463H-11	4.531	38.1	11.9	4.303	38.3	11.3						
364H-4	4.400	36.5	12.0							3.074	22.1	14.2
463H-8	4.372	36.6	11.9	4.630	40.1	11.6						
US H6	4.290	35.5	12.1	4.212	37.2	11.3				2.933	20.9	14.3
US H8	4.227	34.9	12.1							2.652	19.3	14.0
4539H-12	4.097	35.2	11.6							2.493	18.9	13.5
4539H-8	3.999	34.1	11.7							3.404	25.3	13.5
4539H-11	3.958	33.2	12.0									
3425H-4	3.712	30.6	12.1									
F63-549H3	3.676	28.0	13.1	3.901	31.3	12.5						
F64-30H1							2.633	15.9	16.5			
163H5							2.026	12.3	16.5			
GENERAL MEAN	4.297	35.493	12.1	4.439	38.029	11.7	2.607	15.8	16.4	2.921	21.1	14.0
LSD @ P = .05	.437	3.237	.600	N.S.	5.699	.509	N.S.	N.S.	.650	.646	4.940	N.S.
LSD @ P = .01	.579	4.291	.795	N.S.	N.S.	1.116	N.S.	N.S.	.863	.858	N.S.	N.S.
S E of Mean	.155	1.152	.213	.194	1.985	.177	.240	1.451	.231	.229	1.754	.277
S E % of Mean	3.607	3.245	1.760	4.370	5.219	1.512	9.205	9.135	1.408	7.839	8.312	1.978
No. Var. in Test		18			8			16			16	
Planting Date		1-14-65			1-22-65			1-13-65			1-25-65	
Harvest Date		7-15-65			8-19-65			8-15-65			8-12-65	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1965

TEST AREAS:	DEL PASO			DAVIS[1/]		
Variety	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
463H12	3.610	32.03	11.3			
463H8	3.492	30.95	11.4			
363H8				0.760	4.85	15.7
263TH4	3.457	34.34	10.1			
US H7	3.364	29.91	11.4	0.963	6.40	15.2
3425H4	3.361	31.05	10.8			
364H4	3.346	29.20	11.4			
464H14	3.225	30.01	10.8			
US H6	3.172	28.05	11.4	1.229	8.37	14.8
463H11	3.148	29.02	10.9			
4539H8	2.888	26.83	10.7			
3539H8				0.442	2.95	15.5
3539H7				0.470	3.14	14.9
3539H1	2.781	25.37	11.0	0.651	4.32	14.2
US H8	2.759	24.23	11.4	0.483	3.12	15.5
4539H1	2.391	23.20	10.4			
549H3	2.341	20.63	11.4			
363H9				1.101	7.34	15.4
363H7				0.805	5.40	15.2
3539H9				0.586	3.91	15.0
GENERAL MEAN	3.151	28.58	11.1	0.894	5.97	15.1
LSD @ P = .05	0.624	5.79	0.71	0.50	3.39	N.S.
LSD @ P = .01	0.829	7.69	0.94	0.66	4.52	N.S.
S E of Mean	0.222	2.06	0.24	0.17	1.19	0.27
S E % of Mean	7.04	7.21	2.20	19.46	19.93	1.77
No. Var. in Test		16			16	
Planting Date		3-18-65			4-25-64	
Harvest Date		9-22-65			10-18-64	

Remarks: [1/] Heavy nematode infestation in field in which test plot was located.

VARIETY TEST, LE GRAND, CALIFORNIA, 1965

Spring planted — By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	No. Beets 100' Row
464H14	(463H0 x 534) x C164	5678	17.226	16.48	165
263TH4	569H3 x 663T (4n)	5369	16.957	15.83	158
F64-30H4	569H3 x C330	5364	16.753	16.01	147
463H2	US H6	5340	16.381	16.30	157
F64-425H4	569H3 x C3425T (4n)	5327	16.230	16.41	162
463H11	(563H0 x 550) x 663	5131	16.145	15.89	165
L.4126	US H8	4684	15.398	15.21	145
Gen. Mean		5247	16.608	15.80	153
SE Mean		208A/	.588	.28	
LSD (5%)		577	1.637	.77	
SEM/Gen Mean (%)		3.96	3.54	1.76	

VARIATION TABLE

Variation Due to	Degrees of Freedom	Mean Square Tons Beets	Mean Square Percent Sucrose
Variety	35	7.986	1.67
Replication	8	21.053	5.39
Error	280	3.115	.69
Total	323		
Calc. F		2.56**	2.41**

** Exceeds 1% level 1.69

A/ Short Cut Formula

Plot Size: 2 rows (30") x 53' planted - 2 rows x 50' harvested
Design: 6 x 6 triple lattice analyzed as randomized block

Planted: 3/10/65

Harvested: 8/30/65

Harvest: Tons - entire plot: Sucrose 2 25-lb. samples per plot

Remarks: Some tip and crown rot along with lots of watergrass. Good results under these test conditions.

The above results were extracted from a test of 36 varieties.

VARIETY TEST, TULARE, CALIFORNIA, 1965

Spring planted | By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	Percent Purity	No. Beets 100' Row
263TH4	569H3 x C663T	5935	28.618	10.37	86.37	181
463H11	(563HO x 550) x 663	5569	25.975	10.72	88.65	181
F64-30H4	569H3 x C330	5558	24.599	11.30	88.53	188
464H14	(463HO x 534) x 164	5506	24.537	11.22	88.05	177
F64-425H4	569H3 x 3425T	5409	26.157	10.34	88.23	186
4539H11	(563HO x 550) x NB7	5170	23.246	11.12	88.74	183
463H2	US H6	5118	23.654	10.82	87.86	179
L.4126	US H8	4963	22.918	10.83	88.35	195
Gen. Mean		5452	24.585	11.10	88.23	185
SE Mean		250 A/	.990	.24	.68	
LSD (5%)		670	2.767	.67	NS	
SEM/Gen Mean (%)		4.59	4.03	2.18	.77	

VARIATION TABLE

Variation Due to	Degree Freedom	Mean Square Tons Beets	Mean Square Percent Sucrose	Mean Square Percent Purity
Variety	19	15.349	1.29	3.74
Replication	8	34.193	14.11	55.14
Error	152	8.828	.53	4.14
Total	179			
Calc. F		1.74*	2.45**	NS

* Exceeds 5% level 1.71

**Exceeds 1% level 2.12

NS Not Significant

A/ Short Cut Formula

Plot Size: 2 rows (30") x 53' planted - 2 rows x 50' harvested
Design: 4 x 5 rect. lattice - 9 reps - analyzed as randomized block

Planted: 2/12/65

Harvested: 7/20/65

Harvest: Yield - entire plot: Sucrose 2 - 25-lb. samples per plot

Remarks: A good test. Low sugars probably due to high mitrate amounts which were found.

The above results were extracted from a test of 20 varieties.

VARIETY TEST, NORTH TRACY, CALIFORNIA, 1965

Spring planted — By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	No. Beets 100' Row
463H2	US H6	8180	27.525	14.86	152
L.4126	US H8	6918	23.562	14.68	153
Gen. Mean		8050	26.852	15.01	150
SE Mean		377 A/	1.164	.27	
LSD (5%)		1049	3.239	.74	
SEM/Gen Mean (%)		4.68	4.33	1.77	

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square Tons Beets	Mean Square Percent Sucrose
Variety	41	36.452	1.24
Replication	8	145.803	16.70
Error	328	12.193	.64
Total	377		
Calc. F		2.99**	1.95**

** Exceeds 1% level 1.64

A/ Short Cut Formula

Plot Size: 2 rows (30") x 53' planted - 2 rows x 50' harvested
Design: 6 x 7 rectangular lattice analyzed as randomized block

Planted: March 30, 1965

Harvested: November 1, 1965

Harvest: Yield - entire plot: Sucrose 2 - 25-lb. samples per plot

Remarks: Pretty reliable test - no diseases; but quite a bit of water-grass throughout test. First 3 reps. only appeared to be out of N.

The above results were extracted from a test of 42 varieties.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1964-1965

Location: U. S. Department of Agriculture, Southwestern Irrigation Field Station.1/

Soil type: Holtville silty clay loam.

Previous crops: Barley, 1963; fallow, 1964.

Fertilizer used: 44 lbs. per acre phosphorus, actual, preplant.
60 lbs. per acre nitrogen, actual, preplant.
88 lbs. per acre nitrogen, actual, sidedressed December 10-11, 1964.

Planting date: September 10-11, 1964.

Thinning date: October 12-16, 1964.

Harvest dates: Early harvest, April 20-22, 1965.
Late harvest, June 9-10, 1965.

Irrigations: Early harvest, six.
Late harvest, nine.

Diseases and insects: Curly top and yellows viruses infections were light in the 1964-65 plots. The test plot was sprayed with 2 lbs. per acre Malathion on September 20 and 25 for control of cabbage beetle and desert flea beetle. Eight ounces per acre parathion sprayed on plots September 29 for beetle control. An application of Thimet, 10 percent granular, was made January 23, 1965 for control of green peach aphid.

Experimental design: Sixteen varieties planted in a 4 x 4 balanced lattice design, repeated once, two-row plots; and a randomized block test of 12 varieties with ten replications, single-row plots, for early harvest. Ten varieties planted in a 10 x 10 Latin square, two-row plots, for late harvest. Rows spaced 30 inches apart. Plots 40 feet long.

Sugar analysis: From two ten-beet samples per plot by Holly Sugar Corporation, Brawley, California.

Remarks: Test designed and results analyzed by the United States Agricultural Research Station, Salinas, California.

1/ Plot under supervision of K. D. Beatty stationed at Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1965

(10 replications of each variety)
(2 row plots)

Planted: September 10-11, 1964
Harvested: April 19-22, 1965

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
464H8	(562HO x 546) x 464	8,400	24.68	17.1	155
413H4	(562HO x 569) x 413	8,380	24.60	17.1	157
363H8	(562HO x 546) x 663	8,000	22.89	17.5	146
464H11	(563HO x 550) x 464	7,780	22.88	17.0	154
F64-425H11	(563HO x 550) x 3425	7,720	22.61	17.1	140
363H7	(569HO x 563) x 663	7,700	22.48	17.2	147
163H2	(MS of NB1 x NB5) x 663	7,660	22.41	17.1	152
464H14	(563HO x 534) x 464	7,540	21.88	17.4	144
3539H8	(562HO x 546) x NB7	7,460	21.35	17.6	170
F64-30H4	(562HO x 569) x F64-30	7,460	21.89	17.1	149
2539H4	(562HO x 569) x NB7	7,340	21.00	17.5	156
F64-425H4	(562HO x 569) x 3425	7,280	21.11	17.3	152
437H4	(562HO x 569) x 437	7,200	21.11	17.1	162
363H4	(562HO x 569) x 663	7,160	21.18	17.0	156
3539H7	(569HO x 563) x NB7	6,860	20.05	17.3	143
4539H11	(563HO x 550) x NB7	6,720	18.84	17.9	150
General MEAN of all varieties		7,540	21.94	17.3	Beets
S. E. of MEAN		178	0.54	0.17	per
Significant Difference (19:1)		498	1.52	0.47	100'
Coefficient of Variation (%)		7.45	7.83	3.05	row

Odds 19:1 = 1.979 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar 1/	Tons Beets	Percent Sucrose
Between varieties	15	0.55	22.44	0.67
Between replications	9	2.47	134.05	4.71
Remainder (Error)	135	0.079	2.94	0.28
Total	159			
Calculated F value		6.95**	7.64**	2.42**

** Exceeds the 1% point of significance (F=2.20)

1/ Mean squares for gross sugar computed on basis of tons sugar per acre.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1965

Planted: September 10-11, 1964
Harvested: April 19-22, 1965

(10 replications of each variety)
(1 row plots)

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
413H8	(562HO x 546) x 413	8,880	29.10	15.3	151
437H8	(562HO x 546) x 437	8,420	26.94	15.6	152
437	YRS 663	8,320	28.33	14.8	145
163H2	(MS of NB1 x NB5) x 663	8,280	26.28	15.8	148
263TH4	(562HO x 569) x 663T	8,100	26.15	15.5	135
F64-30H8	(562HO x 546) x F64-30	7,800	26.63	15.3	147
413	YRS US 75	7,420	24.16	15.4	139
F64-30	YRS US 75	7,400	23.85	15.5	135
456H4	(562HO x 569) x 456	7,000	21.78	16.2	147
472H4	(562HO x 569) x 472	6,520	18.83	17.4	147
4404H8	(562HO x 546) x 4404	6,340	19.15	16.7	136
F57-68	US 75	6,120	19.41	15.8	144
General MEAN of all varieties		7,560	24.14	15.8	Beets
S. E. of MEAN		344	1.19	0.23	per
Significant Difference (19:1)		964	3.34	0.65	100'
Coefficient of Variation (%)		14.40	15.59	4.67	row

Odds 19:1 = 1.984 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar 1/	Tons Beets	Percent Sucrose
Between varieties	11	2.02	129.04	4.79
Between replications	9	0.06	4.17	1.96
Remainder (Error)	99	0.30	14.16	0.54
Total	119			
Calculated F value		6.81**	9.11**	8.84**

** Exceeds the 1% point of significance (F=2.43)

1/ Mean squares for gross sugar computed on basis of tons sugar per acre

VARIETY TEST, BRAWLEY, CALIFORNIA, 1965

(10 x 10 Latin Square)

Planted: September 10-11, 1964
Harvested: June 9, 1965

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
464H11	(563HO x 550) x 464	11,260	33.83	16.7	152
464H8	(562HO x 546) x 464	11,180	33.47	16.7	161
464H14	(563HO x 534) x 464	10,840	32.18	16.8	153
2539H4	(562HO x 569) x NB7	10,660	31.03	17.2	158
163H2	(MS of NB1 x NB5) x 663	10,520	32.39	16.3	160
F64-425H11	(563HO x 550) x 3425	10,440	31.22	16.7	152
363H7	(569HO x 563) x 663	10,200	30.24	16.9	158
3539H7	(569HO x 563) x NB7	9,920	29.26	17.0	154
3539H8	(562HO x 546) x NB7	9,780	28.47	17.2	167
363H4	(562HO x 569) x 663	9,780	29.49	16.6	159
General MEAN of all varieties		10,460	31.16	16.8	Beets
S. E. of MEAN		231	0.67	0.10	per
Significant Difference (19:1)		652	1.90	0.29	100'
Coefficient of Variation (%)		6.99	6.82	1.92	row

Odds 19:1 = 1.994 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar 1/	Tons Beets	Percent Sucrose
Between varieties	9	0.73	32.85	0.80
Between replications	9	0.37	15.06	0.41
Between columns	9	0.32	14.10	1.00
Remainder (Error)	72	0.134	4.52	0.10
Total	99			
Calculated F value		5.47**	7.27**	7.65**

** Exceeds the 1% point of significance (F=2.67)

1/ Mean squares for gross sugar computed on basis of tons sugar per acre.

VARIETY TEST, EL CENTRO, CALIFORNIA, 1964-65

Grower and location: Lerno Brothers, El Centro, California.

Soil type: Holtville clay loam.

Previous crops: Alfalfa, 1962, 1963 and 1964.

Fertilizer used: 28 lbs. per acre nitrogen, actual, preplant.
53 lbs. per acre phosphorus, actual, preplant.
164 lbs. per acre nitrogen, actual, sidedressed.

Planting date: September 28, 1964.

Thinning date: Late November.

Harvest date: July 8-9, 1965.

Irrigations: Twelve.

Diseases and insects: Only mild infections of virus yellows and mosaic occurred in the field where test plot was located. Plot was sprayed once in October for control of cutworm, cabbage beetle and desert flea beetle.

Experimental design: Eight varieties planted in an 8 x 8 Latin square design. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division Tare Laboratory, El Centro, California.

Remarks: Seed was furnished, test designed, and results analyzed by the United States Agricultural Research Station, Salinas, California. Plot planted, observed throughout season and harvested by K. D. Beatty, Southwestern Irrigation Field Station, Brawley, California, in cooperation with Union Sugar Division.

VARIETY TEST, EL CENTRO, CALIFORNIA, 1965

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
464H11	(563HO x 550) x 464	14,520	44.68	16.3	165
464H14	(563HO x 534) x 464	13,280	39.95	16.6	168
363H7	(569HO x 563) x 663	13,260	40.35	16.4	176
363H4	(562HO x 569) x 663	13,160	39.78	16.6	181
2539H4	(562HO x 569) x NB7	13,060	38.41	17.0	174
3539H8	(562HO x 546) x NB7	12,940	38.16	17.0	177
163H2	(MS of NB1 x NB5) x 663	12,780	38.75	16.5	171
3539H7	(569HO x 563) x NB7	12,400	37.64	16.5	167
General MEAN of all varieties		13,180	39.72	16.6	Beets
S. E. of MEAN		167	0.43	0.12	per
Significant Difference (19:1)		520	1.33	0.38	100'
Coefficient of Variation (%)		3.59	3.04	2.09	row

Odds 19:1 = 2.02 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar 1/	Tons Beets	Percent Sucrose
Between varieties	7	0.75	39.37	0.53
Between replications	7	0.18	6.51	0.43
Between columns	7	0.19	8.42	0.40
Remainder (Error)	42	0.056	1.46	0.12
Total	63			
Calculated F value		13.47**	26.97**	4.39**

** Exceeds the 1% point of significance (F=3.10)

1/ Mean squares for gross sugar computed on basis of tons sugar per acre.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1965

Cooperative with USDA — By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield: Gross Sugar	Acre Yield: Tons Beets	Percent Sucrose	Percent Purity	No. Beets 100' Row	Seedling Vigor Rating 10/19/64	Top Vigor Rating 7/12/65
2539H4	(562HO x 569) x NB7	8181	31.983	12.79	87.43	189	3.2	3.0
464H14	(563HO x 534) x 464	7846	31.037	12.64	87.71	185	2.4	2.6
464H11	(563HO x 550) x 464	7640	32.262	11.84	89.34	187	2.5	2.9
3539H7	(569HO x 563) x NB7	7271	29.461	12.34	88.68	187	3.0	2.5
363H7	(569HO x 563) x 663	7091	28.921	12.26	88.60	182	2.6	3.1
3539H8	(562HO x 546) x NB7	7085	28.362	12.49	89.31	196	2.5	2.9
363H4	(562HO x 569) x 663	7002	28.304	12.37	88.54	194	1.9	3.0
163H2	(MS of NB1 x NB5) x 663	6867	28.352	12.11	88.09	194	1.5	3.5
Gen. Mean		7373	29.835	12.35	88.46	189		
SE Mean		160 A/	.512	.15	.38			
LSD (5%)		457	1.463	.47	1.08			
SEM/Gen. Mean (%)		2.94	1.72	1.32	.42			

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square: Tons Beets	Mean Square: Percent Sucrose	Mean Square: Percent Purity
Variety	7	22.444	.72	3.84
Rows	7	19.381	1.50	8.16
Columns	7	6.685	1.18	2.79
Error	42	2.097	.21	1.15
Total	63			
Calc. F Value		10.70**	3.36**	3.34**

** Exceeds 1% level 2.96

A/ Short Cut Formula

Seedling Vigor Rating: Rating from 0-10, 1 being high

Top Vigor Rating: Rating from 1-5, 5 being high

Plot Size: 2 rows (34") x 53' Planted - 2 rows x 50' harvested. Design: 8 x 8 Latin Square.

Planted: September 18, 1964. Harvested: July 13, 14, 1965. Irrigated: September 28, 1964.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1965

First Date of Harvest — By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	Percent Purity	Top Vigor Rating 2/ 1/22/65	Seedling Vigor Rating 1/ 10/20/64	No. Beets 100' Row
US H8	563H3 x NB7	4562	16.651	13.70	87.53	7.1	6.6	169
3539H7	(569HO x 563) x 0539	4156	15.827	13.13	87.76	7.1	7.0	161
4539H11	(563HO x 550) x NB7	4012	15.585	12.87	87.35	6.3	6.4	160
US H6	(NB1MS x NB5) x 663	3882	15.442	12.57	86.74	7.3	8.4	172
Gen. Mean		4227	16.133	13.10	87.56	7.4	7.1	161
SE Mean		154 A/	.506	.25	.47			
LSD (5%)		431	1.417	NS	NS			
SEM/Gen. Mean (%)		2.64	3.14	1.87	.54			

VARIATION TABLE

Variation Due to	Degrees of Freedom	Mean Square Tons Beets	Mean Square Percent Sucrose	Mean Square Percent Purity
Variety	15	6.947	.901	2.27
Replication	8	18.110	5.325	5.23
Error	120	2.308	.542	2.02
Total	143			
Calc. F		3.01**	NS	NS

** Exceeds 1% level 2.23

NS Not Significant

A/ Short Cut Formula

2/ Top Vigor Rating - 1/22/65 - Scale 0-10, 10 being high

1/ Seedling Vigor Rating - 10/20/64 - Scale 0-10, 10 being high

Plot Size: 2 rows (34") x 53' planted - 2 rows x 50' harvested. Design: 4 x 4 Triple Lattice - 9 reps. Planted: September 16, 1964. Irrigated: September 28, 1964. Harvested: April 17, 1965. Harvest: Yield - entire plot; Sucrose 2 - 25-lb. samples per plot.

Remarks: No problems - fine test.

The above results were extracted from a test of 16 varieties.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1965

Second Date of Harvest | By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	Percent Purity	Top Vigor Rating 2/ 5/17/65	Seedling Vigor Rating 1/ 10/20/64	No. Beets 100' Row
US H8	569H3 x NB7	7726	25.771	14.99	89.66	2.9	6.3	171
3539H7	(569HO x 563) x 0539	7071	24.353	14.78	89.50	2.8	6.3	166
US H6	(NB1MS x NB5) x 663	7068	24.696	14.31	89.54	3.9	8.1	178
4539H11	(563HO x 550) x 0539	6757	23.189	14.57	89.48	2.3	6.0	163
Gen. Mean		7187	24.266	14.83	89.85			168
SE Mean		189 A/	.544	.20	.33			
LSD (5%)		528	1.523	.57	.92			
SEM/Gen. Mean (%)		2.63	2.24	1.38	.36			

VARIATION TABLE

Variation Due to	Degrees of Freedom	Mean Square Tons Beets	Mean Square Percent Sucrose	Mean Square Percent Purity
Variety	15	10.716	3.71	2.31
Replication	8	60.406	.79	15.37
Error	120	2.667	.38	.96
Total	143			
Calc. F		4.02**	2.11*	2.40**

** Exceeds 1% level 2.23 - * Exceeds 5% level 1.77
A/ Short Cut Formula - 1/ Seedling Vigor Rating - 10/20/64 - Rating from 0-10, 10 being high - 2/ Top Vigor Rating - 5/17/65 - Rating from 1-5, 5 being high

Plot Size: 2 rows (34") x 53' planted - 2 rows x 50' harvested. Design: 4 x 4 Triple Lattice - analyzed as a randomized block. Planted: September 18, 1964. Irrigated: September 28, 1964. Harvested: June 3, 1965. Harvest: Tons - entire plot; Sucrose 2 - 25-lb. samples per plot.

Remarks: Good test.

The above results were extracted from a test of 16 varieties.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1965

Third Date of Harvest — By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	Percent Purity	No. Beets 100' Row	Seedling Vigor Rating 1/ 10/19/64	Top Vigor Rating 2/ 7/12/65
US H8	569H3 x NB7	7576	27.591	13.73	89.94	174	4.6	2.3
3539H7	(569HO x 563) x 0539	6918	26.508	13.05	88.77	171	6.4	2.1
US H6	(NB1MS x NB5) x 663	6734	26.768	12.58	88.94	180	7.2	3.4
4539H11	(563HO x 550) x NB7	6129	23.559	13.01	89.90	154	4.9	1.4
Gen. Mean		6922	26.268	13.17	89.43	172		
SE Mean		222 A/	.638	.28	.52			
LSD (5%)		621	1.785	.77	NS			
SEM/Gen. Mean (%)		3.21	2.43	2.09	.58			

VARIATION TABLE

Variation Due to	Degrees of Freedom	Mean Square Tons Beets	Mean Square Percent Sucrose	Mean Square Percent Purity
Variety	15	10.844	1.54	3.84
Replication	8	10.695	3.36	11.63
Error	120	3.661	.68	2.39
Total	143			
Calc. F		2.96**	2.25**	NS

** Exceeds 1% level 2.23 - NS Not Significant - A/ Short Cut Formula
1/ Seedling Vigor - 10/19/64 - Scale 0-10, 10 being high - 2/ Top Vigor - 7/12/65 - Scale 1-5, 5 being high

Plot Size: 2 rows (34") x 53' planted - 2 rows x 50' harvested. Design: 4 x 4 Triple Lattice - Planted: 9/18/64. Irrigated: 9/28/64. Harvested: 7/13-14/65. Harvest: Yield - entire plot; Sucrose 2 - 25-lb. samples per plot.

Remarks: Excellent test.

The above results were extracted from a test of 16 varieties.

DEVELOPMENT OF TRIPLOID AND TETRAPLOID SUGARBEETS

B. L. Hammond

Seed increases of the following tetraploid selections are being made: 585T (F57-85T); 585HOT; 5563T (1561-16-7C1T); 5509T (F59-509R-C_1); 4562T; 4562HOT; 1515T (F61-515T); 552T; 1547T; 330R-T; 164R-T; F58-554rrT; and 586rrT. Seed was planted in Oregon in August 1965. Stecklings will be brought to Salinas in March 1966 and isolated.

In September 1963, 34 grams of C_1 seed were harvested from the type O monogerm inbred, F61-515 (1515). Some of the seed was planted in February 1965. Fifty-five tetraploid plants were placed under thermal induction in April for a seed increase. These were removed in October 1965 and are now being selfed. An additional planting was made in November 1965 for isolation in the spring of 1966 to supplement material of this selection to be brought from Oregon. Since nearly 100 percent of the plants have red hypocotyls, this inbred should be of value in outcrossing studies.

Seedlings of the vigorous multigerm inbred 1547 (from NB5) were colchicine-treated in July 1962 and placed under thermal induction in October. Twenty-eight plants had green hypocotyls; and 20, red hypocotyls. All were removed from the coldroom in April 1963, and each class interpollinated separately. In September, 15 gms. of C_1 seed were harvested from plants with green hypocotyls and 26 gms. from plants with red hypocotyls. For the purpose of securing additional seed from plants with red hypocotyls for use in outcross studies, a second planting of colchicine-treated seedlings of this material was made. Fifty-eight plants having red hypocotyls were placed under thermal induction in March 1963 and removed in July for interpollination. In January 1964, 29 gms. of C_1 seed were obtained. Ten grams of seed were planted in Oregon in August 1965 for an additional seed increase. Forty plants of 1547rrT and 62 plants of 2559-1RRT were placed under thermal induction in May 1965 and removed in October for crossing. Tetraploid plants of 1547R-T have been crossed to 2423T (T8 increase) and to 2539T, a multigerm, tetraploid inbred from NB7.

In July 1962, pregerminated seed of multigerm 586 was colchicine-treated. On the basis of cytological observations, 62 plants were selected for thermal induction and placed in the coldroom in December. They were removed in July 1963 and interpollinated. Twenty plants had green hypocotyls and 42, red hypocotyls. Twelve gms. of C_1 seed were obtained from plants with green hypocotyls and 18 from the red-hypocotyl plants. This selection is an open-pollinated multigerm. It is high in sucrose percentage but low in root yield. Crosses were made with 663T and with 871T in an attempt to develop a tetraploid topcross parent with good tonnage and sucrose percentage. Seed for these crosses was planted in March 1964. Plants were placed under thermal induction in

June 1964. Additional C_1 seed of 586 was planted also for a small seed increase. Twenty-one plants were placed under thermal induction in May 1964. These were removed in September and sib-crossed. Seed was planted in Oregon in August 1965 for further seed increase.

Colchicine-treated seedlings of the multigerm inbred F59-509 (NB3) (5509T) were planted in August 1962 and transplanted to pots in November. In January 1963, 38 selected C_o plants were exposed to thermal induction and removed in July for sib crossing. Only 5.2 grams of seed were obtained, some of which were planted in March 1964 for seed increase. Thirty-eight tetraploid plants were placed under thermal induction in May. Thirteen of these were removed in September for a seed increase. After not having bolted by February 1965, they were returned to the coldroom. The remaining 25 plants were removed in February 1965. Instead of using these in crosses as was planned, seed increases are being made of these very weak inbreds. All plants have red hypocotyls, a characteristic which will facilitate studies in outcrossing involving tetraploids derived from self-fertile diploid inbreds.

Pregerminated seed of selection F58-554 (NB4) were treated with colchicine and planted in October 1962. They were transplanted to pots in December 1962. Seventy-four selected C_o plants were placed in the coldroom for thermal induction in March 1963 and removed in August for interpollination. Thirty-seven gms. of C_1 seed were obtained. Ten grams of seed were planted in Oregon in August 1965 for a seed increase. This selection is a small-seeded, multigerm inbred. All plants have green hypocotyls.

In November 1962, pregerminated seed of selection 2559-1 was colchicine-treated. Seedlings were potted in January 1963. Sixty-seven C_o plants selected on the basis of cytological examination were placed under thermal induction in May 1963 and removed in August for interpollination. After 5 weeks with no evidence of bolting, these plants were returned to the coldroom for further thermal induction. Plants were again removed from the coldroom in March 1964 and later sib-crossed. Forty-three gms. of C_1 seed were obtained. Seed of this selection was planted in November 1964 for crossing to 1547. This selection is a multigerm inbred similar to NB1. It has red hypocotyls and petioles, a character which will facilitate studies in outcrossing.

Pregerminated seed of selection 164, a bolting resistant selection from 663, was colchicine-treated in June 1963. Seventy-eight selected C_o plants (68 with red hypocotyls and 10 with green hypocotyls) were placed under thermal induction in September. These were removed in March 1964 and interpollinated. From plants with red hypocotyls 54 gms. of good seed were obtained. It is doubtful if any good seed was obtained from plants with green hypocotyls. C_1 seed from plants with red hypocotyls was planted in February 1965 for seed increase. Plants were placed in the coldroom in April 1965 and removed in October 1965. These are now being interpollinated.

One-hundred fifty-five colchicine-treated seedlings of selection 330 were transplanted to pots in September 1963. Seventy of these (16 with green hypocotyls and 54 with red hypocotyls) were placed in the coldroom for thermal induction in December 1963. Plants were removed from the coldroom in June 1964 and sib-crossed. Twenty-seven grams of C_1 seed were produced from plants with red hypocotyls; four grams were obtained from plants with green hypocotyls. Nineteen grams of seed from plants with red hypocotyls were planted in Oregon in August 1965 for a seed increase. Four grams of seed from plants with green hypocotyls were planted at Salinas in September 1965 for a seed increase. Seventy-three C_1 plants were obtained. Selection 330 is a selection from the self-sterile, multigerm, US 75, and is yellows resistant.

Colchicine-treated seedlings of selection 952 were planted in July 1963 and transplanted to pots in September. Sixty-seven desirable C_0 plants were selected for thermal induction in January 1964. This is a self-sterile, type O selection from US 15. Plants were removed from the coldroom in June 1964 and later interpollinated. Eighteen grams of C_1 seed were obtained. Twelve grams were planted in Oregon in August 1965 for seed increase. An additional 6 grams were planted at Salinas in November 1965 to supplement seed planted in Oregon.

In April 1964, pregerminated seed of the self-fertile multigerm 3757 was colchicine-treated. One-hundred fifty-five seedlings with red hypocotyls were potted in May. On the basis of cytological examination, 75 of these were placed under thermal induction in July. Thirty-three seedlings with green hypocotyls were potted in June. Nineteen of these were placed in the coldroom in September. Plants were removed in March 1965 and interpollinated. Fifty-three grams of C_1 seed were obtained from plants with red hypocotyls and 11 grams from plants with green hypocotyls. This selection is yellows resistant.

Colchicine-treated seedlings of the self-fertile, monogerm inbred 3534 planted in April 1964 were potted in July. Of the 155 transplanted, 70 were selected for thermal induction in October. These were removed from the coldroom in June 1965 and interpollinated. Seven grams of C_1 seed were harvested. All plants have green hypocotyls. This selection responded well to the 0.3 percent colchicine solution.

Pregerminated seed of the self-fertile, yellows-resistant multigerm 3716-18 was colchicine-treated and planted in April 1964. One-hundred fifty-five seedlings were transplanted to pots in June. Fifty-two plants (mostly poor chimeras) were placed in the coldroom in August. These were removed in April 1965 and interpollinated. Thirty-seven grams of C_1 seed were produced. All plants have red hypocotyls. This selection did not respond well to the 0.3 percent colchicine solution.

One-hundred five colchicine-treated seedlings of selection 3550 were transplanted to pots in July 1964. Sixty-eight of these (indicating good response to the 0.3 percent colchicine solution) were selected for thermal induction in December. These were removed from the coldroom in July 1965 and selfed. One gram of C_1 seed was harvested. This is a bolting resistant, monogerm inbred.

In August 1964, pregerminated seed of selection 3753 was colchicine-treated. One-hundred fifty-five seedlings were transplanted to pots in September. On the basis of cytological examination, 52 (including some poor chimeras) were selected for thermal induction in November. These were removed from the coldroom in July 1965 and interpollinated. Twenty-one grams of seed were obtained. This is a yellows-resistant multigerm and has red hypocotyls. This selection did not respond well to the 0.3 percent colchicine solution.

Pregerminated seed of the inbred monogerm 4764 was treated with colchicine and planted in August 1964. Seedlings were highly infected with root rot. Of the 125 seedlings transplanted to pots in November, 21 had green hypocotyls. Eighteen C_o plants with green hypocotyls and 56 with red hypocotyls were placed under thermal induction in February 1965. These were removed in July and selfed. The eighteen plants with green hypocotyls were placed in an isolation chamber. This selection is yellows-resistant.

Germinating seed of 234, a self-sterile, yellows-resistant selection obtained from Dr. Rietberg, was colchicine-treated and planted in November 1964. Sixty-five promising chimeras were selected for thermal induction in August 1965. 234 has both green and red hypocotyls.

Colchicine-treated seed of the multigerm 413B was planted in November 1964. Seventy promising C_o plants were placed under thermal induction in April 1965. These were removed in November 1965 for interpollinating. It is a yellows-resistant selection from US 75. All seedlings have green hypocotyls.

Pregerminated seed of the multigerm, inbred selection 4704 was planted in November 1964. It is also resistant to virus yellows. Sixty-eight desirable chimeras were placed in the coldroom in June 1965. All plants have red hypocotyls.

Pregerminated seed of the monogerm inbred 4806 from F57-85 was colchicine-treated and planted in May 1965. One-hundred fifty-five seedlings were transplanted to pots in June 1965. Sixty-eight good chimeras were placed under thermal induction in September 1965. This selection has green hypocotyls.

One-hundred fifty colchicine-treated seedlings of selection 4742 were transplanted to pots in August 1965. Seventy plants were selected for thermal induction in October. This multigerm inbred has red hypocotyls and is yellows resistant.

In June 1965, pregerminated seed of selection F60-512 was colchicine-treated. One-hundred fifty seedlings were potted in September. This is a bolting-resistant, multigerm inbred.

Germinating seed of 4754, a yellows-resistant, multigerm inbred-selection, was colchicine-treated in August 1965 and transplanted to pots in November.

562HO-T X 1546-22T (546-22H3T).--A history of this cross was given in the 1963 report. A planting of this cross, in addition to one of the pollen-fertile parent, 1546-22T, was made in Oregon in August 1964 for additional seed increases. Stecklings of both were isolated together at Salinas in March 1965. Fifty-six grams of seed were harvested from 546-22H3T and 44 grams from 546-22T. Plantings of these 2 lines were repeated in Oregon in August 1965 for additional seed increases at Salinas.

562HO-T X 563T.--Seedlings of the male-sterile, monogerm inbred line, 562HO-T and the tetraploid selection of 1561-16-7Cl (563T) were exposed to thermal induction in July 1963, moved to the greenhouse in February 1964 and crossed. A number of the pollen-fertile parent, 563T, was sib-crossed. Thirty-two gms. of seed were obtained from 562HO-T X 563T and 17 gms. from 563T. Plantings of both classes of seed were made in Oregon in August 1965 for additional seed increases. The diploid form of the latter selection has been made available through the Foundation as C2563. It is a type O monogerm and highly resistant to curly top.

2423T (T8 Increase) X 1547T.--In December 1963, seed of 2423T, together with seed of the multigerm inbred, 1547T, was planted for the purpose of making crosses between these two selections. 2423T is a composite seed increase of a number of T8-line single-plant tetraploid selections derived from S_6(US22/3 X NB1). Plants were placed under thermal induction in May 1964 and removed in December for crossing. The gene for red hypocotyl in 1547T was to be used in identifying crosses. Since these 2 lines are self fertile, 2423T was treated with the gametocide, FW450, in an attempt to increase the amount of hybrid seed. FW450 has been used at this station with some success. However, in this case all treated plants were killed and, therefore, no seed was obtained. In actual field tests, line 2523T has not shown any promise.

871T X 0539T.--Seed of this cross will be planted in Oregon in August 1966 for an additional seed increase.

2539T X 1547T.--In December 1963, tetraploid seed of the multigerm inbred, 2539 (from NB7), together with seed of another tetraploid, multigerm inbred, 1547T, was planted. Plants were placed under thermal induction in May 1964 and removed in December for crossing. A very small amount of seed (46 seeds) was obtained from the female parent, 2539T, which has green hypocotyls. 1547T has red hypocotyls and this gene will be used in identifying crosses.

F62-63T X 586T.--Seed of the multigerm, F62-63T (663T), together with seed of the multigerm 586T, was planted in March 1964. Plants were placed under thermal induction in June 1964. They were removed in February 1965 and cross pollinated. Seven grams of seed were harvested from the female parent, F62-63T, which has green hypocotyls. The gene for red hypocotyls in 586T will be used in identifying crosses. 586 is high in sucrose percentage but low in root yield. This cross was made in an attempt to develop a tetraploid top-cross parent with good tonnage and sucrose percentage.

271T X 586T.--This cross also is being made with the view of developing a tetraploid top-cross parent with good tonnage and sucrose percentage. 271T is a type O multigerm. Seed was planted in March 1965. The plants were placed under thermal induction in June 1964 and removed in January 1965 and cross pollinated. Eleven grams of seed were obtained from the female parent, 271T, which has green hypocotyls. 586T has red hypocotyls, and this gene will be used in identifying crosses.

1547T X 2559-IT.--Seed of the multigerm inbred 1547, together with seed of the multigerm inbred 2559-1T, was planted in November 1964 for crossing. Thirty-nine plants of 1547rrT and 64 plants of 2559-1RRT were placed in the coldroom in the spring of 1965. These were removed in September 1965 and are now being cross pollinated.

562HO-T X 4546-48T (5546-48H3T).--Seed of the male-sterile line, 562HO-T, and of the type O monogerm inbred, 4546-48T, was planted in Oregon in August 1964 for the purpose of obtaining another male-sterile tetraploid line for use with diploid pollinators. Stecklings of these two lines were isolated together at Salinas in March 1965. Forty-nine grams of seed were harvested from 546-48H3T and 267 grams from 546-48T. Plantings of these 2 lines were repeated in Oregon in August 1965 for additional seed increases at Salinas.

The finding of a haploid sugarbeet was reported in 1963. The number of plants was increased by vegetative propagation of flower-stalk cuttings and grafts of root-crown cuttings. Fertile, homozygous seed was obtained by the application of colchicine in the leaf axils of the crown where flower stalks were beginning to form. A high percentage of the seed was diploid, from which a seed increase of more than $1\frac{1}{2}$ pounds was made in the greenhouses during the summer of 1965. Seed was also planted in Oregon in August 1965 for an additional seed increase in isolation there. (See 1964 Report, page 64.)

Additional seed increases of the tetraploid form of the monogerm, inbred 0546-36 have been made. Earlier reports indicated that the tetraploid form of this selection was highly resistant to the two-spotted mites in the Salinas greenhouses, whereas the diploid form was highly susceptible.

Test Reports.--The two-spotted mites in the Salinas greenhouses are becoming increasingly resistant to acaricide spray mixtures. In view of this, some of the systemic miticides are being tested. Preliminary experiments with UC 21149 10% Granular are showing considerable promise. This is a product manufactured by Union Carbide Corporation and is obtainable at this time only for experimental purposes. Only a small quantity (0.1-0.2 gram) was needed per 6-inch pot. Amounts much greater than this caused a severe burning of the leaf margins. The material is rather light and, for this reason, it was buried in an opening beneath the surface of the soil in each pot to avoid its being washed away. The effects of the miticide became evident in 5 or 6 days after treatments, when only dead or dying mites were observed. No live mites were observed on the plants 3 weeks after treatment (at the time this report was written). Since this systemic miticide has been found effective also in controlling aphis, its use in isolation chambers would be worthy of consideration.

A preliminary experiment with the commercially available, systemic miticide, Thimet (Cyanamid Corporation), did not show any promise in controlling mites in the Salinas greenhouses. Applications were made in accordance with instructions for its use at the Cotton Field Station in Shafter, California where it was found effective in controlling their mites on potted cotton plants. Stronger applications than those recommended will be used in further trials at Salinas.

P A R T III

BREEDING FOR YELLOWS RESISTANCE

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PROGRESS IN BREEDING FOR YELLOWS RESISTANCE

J. S. McFarlane, I. O. Skoyen, and R. J. Hecker

Work was continued in 1965 to select breeding lines with improved resistance to yellows. Selections made in previous years were evaluated for resistance in tests at Davis, California. Hybrids utilizing yellows-resistant selections as the pollen parent were included in variety tests grown under severe yellows conditions and under conditions relatively free of yellows.

Plans and Procedures

Three evaluation tests were planted at Davis, California, on May 12, 1965. The first test included nine open-pollinated selections which had been made at Salinas on the basis of root size and freedom from yellowing. Two selections from US 75 made by Dr. J. M. Fife on the basis of amino-acid ratio and root size were included. The test also included the parental lines from which the selections had been made and a yellows-resistant selection from The Netherlands.

A second test included ten inbred lines selected for yellows resistance. Nonselected inbreds and male steriles commonly used in hybrid varieties were also tested. The third test was designed to test hybrids involving both open-pollinated and self-fertile yellows-resistant selections. In each hybrid, the seed-bearing parent was a male-sterile monogerm which had not been selected for yellows resistance.

A modified split-plot design was used for all tests. The treatments, consisting of a noninoculated check and a combination beet and western-yellows inoculation, were arranged in randomized strips across each of five replications. The variety subplots were two rows wide and 41 feet long. In the first test the parental groups were randomized within the replications, and the selections or varieties randomized within the parental groups. The entries in tests two and three were arranged at random. Stand counts were made following thinning and plant populations adjusted so that a similar number of plants remained in the inoculated and noninoculated plots of any given entry in each replication. Difficulties were experienced with aphid production and inoculations were not made until August 5, about one month later than in previous years. The plants were very large with roots about three inches in diameter. Inoculations were with a virulent (Brawley) strain of beet yellows and a virulent strain of western yellows. A high percentage of the plants in the inoculated plots became infected. Some scattered infection with mosaic and yellows occurred in the check plots. The tests were harvested October 25-27.

Selections for yellows resistance were made at Salinas from beets planted February 18 and April 28. The February planting included both open-pollinated and inbred lines which had been selected for yellows resistance in previous years. F_2 populations from crosses between yellows-resistant selections and monogerm inbreds were also included. The April planting included blocks of the bolting-resistant selection 264 and of the yellows-resistant selection 234. This planting was planned as the commencement of a reciprocal recurrent selection program. The selection 264 was thinned to a normal spacing of about eight inches, but thin stands necessitated a spacing of 24-30 inches in 234. The February planting was inoculated May 13 and the April planting, June 21. The same combination of viruses was used as in the Davis tests. Aphid populations were high during the early spring, and natural infection with yellows occurred prior to inoculation in the March planting.

Hybrids utilizing yellows-resistant selections as pollen parents were produced in 1964. These hybrids were included in 1965 variety tests at Salinas, King City, San Lucas, and Brawley. Yellows infection was heavy in the Salinas and King City tests, moderate in the San Lucas test, and light in the Brawley test.

Results and Discussion

Favorable conditions existed for emergence in the Davis tests, and good stands were obtained with nearly all entries. A fertility gradient occurred from the top to the bottom of the field. This gradient affected the severity of yellowing and also caused a variation in root yield from one end of the field to the other. The month's delay in inoculation resulted in reduced stunting and a smaller root-yield loss from yellows than occurred in previous tests.

The root-yield losses averaged 11 percent for the selections, 11 percent for the hybrids, and 17 percent for the inbreds. In the 1964 test, root-yield losses averaged 31 percent for the selections, 30 percent for the hybrids, and 28 percent for the inbreds. The 1965 losses were less than one-half the magnitude of the 1964 losses even though a more virulent strain of the beet-yellows virus was used. These results substantiate earlier findings that the age of the plant at the time of infection has an important bearing on the amount of damage produced.

Even though varietal differences in percentage root-yield loss were not significant in the 1965 tests, the results demonstrate that progress has been made in developing breeding lines which perform well when infected with yellows. The most extensive work has been with selections from US 75. Four US 75 selections, based on root size and freedom from yellowing, were included in the Davis test as were two selections made by Dr. J. M. Fife on the basis of root size and amino-acid pattern (table 1). Selections 413 and 430 originated from US 75 but were separated in the fourth cycle of selection. 430A was separated

from 430B in the fifth cycle of selection. Likewise, 413A was separated from 413B in the fifth cycle of selection. The 413A selection showed the greatest promise with a root-yield advantage of 4.7 tons per acre in the inoculated plots over US 75. Sucrose determinations were not made at Davis.

The 1965 Davis tests failed to provide new information on the relative yellows resistance of inbred selections (table 2). Highly significant differences in root-yield losses were observed among inbreds in 1964.

Root yields of three-way hybrids involving yellows-resistant selections were high in both the inoculated and noninoculated plots at Davis (table 3). These hybrids were also included in five California variety tests and the results are summarized in tables 4 and 5. Complete results may be found in Part II, "Development and Evaluation of Inbred Lines and Hybrid Varieties of Sugarbeets Suitable for California." Hybrids with 413C showed the greatest promise. 413C is the fifth successive yellows-resistant selection from US 75 and is the line from which 413B was selected. Not only did these hybrids perform well in the coastal valleys when infected with yellows, but they also yielded well in the Imperial Valley under relatively yellows free conditions. The sucrose percentage of these hybrids was satisfactory even though 413C had been selected primarily on the basis of root size.

In four California variety tests the root yield of 413H4 was 3.3 to 5.9 tons per acre higher than the yield of US H7 (table 6). The sucrose percentage of the two hybrids was similar in three tests and significantly higher for 413H4 in the third test. Tests at Salinas and at Thatcher, Utah, showed 413H4 to be equal or superior to US H7 in bolting and curly-top resistance. US H7 and 413H4 have a common monogerm seed-bearing parent, 562HO x 569.

Hybrids involving the selection 330 yielded well, but the results were less promising than with 413C (tables 4 and 5). 330 is a fifth successive selection from US 75 and is the line from which 430B was selected. The 437 hybrids, which utilized a yellows-resistant selection from 663 as the pollen parent, failed to show any superiority in the 1965 tests.

Selections based on freedom from yellowing, root size, and sucrose percentage were made from the February planting at Salinas. Particular emphasis was placed on a selection from 413B. This line showed less yellowing following inoculation with yellows than did other selections. The roots were large, with considerable variation in root size and sucrose percentage. Selections based on root size and sucrose percentage were also made from 264 and 234 in the April 28 planting.

Table 1. Comparison of the root yield of yellows inoculated sugar-beet selections with non-inoculated checks at Davis, California, in 1965.

Selection	Description	Acre Yield Check	Acre Yield Inoc.	Harvest Count Check	Harvest Count Inoc.
		Tons	Tons	Number	Number
413A	6th YRS US 75	31.92	28.18	146	150
413B	6th YRS US 75	30.39	27.98	139	138
433A	2nd YRS 663	33.17	27.98	142	137
430B	6th YRS US 75	29.73	27.61	134	134
437A	2nd YRS 663	31.98	27.38	135	141
419	4th YRS 55-RF-393	30.17	27.33	149	148
421B	4th YRS 671	29.21	26.37	129	125
430A	6th YRS US 75	28.26	24.98	133	135
413DS-23	1st YRS US 75 (Fife)	26.01	24.20	135	132
438	2nd YRS F57-85	26.29	23.61	127	127
F57-63	Inc. of 663	27.67	23.53	139	142
F57-68	US 75	27.04	23.47	132	129
234	YRS from Rietberg	24.89	23.26	109	99
122RS-C	2nd YRS US 75 (Fife)	24.94	23.21	133	126
671	Type O line	25.16	22.05	126	126
F57-85	Type O US 75	19.00	17.30	117	116
	L.S.D. (5%)	2.22	1.95	Beets per 100' row	

Table 2. Comparison of the root yield of yellows inoculated sugar-beet inbreds with non-inoculated checks at Davis, California, in 1965.

Inbred	Description	Acre Yield		Harvest Count	
		Check	Inoc.	Check	Inoc.
		Tons	Tons	Number	Number
4734A	YRS (927-35 x 5577-2)	28.72	25.40	132	132
4716-18	YRS (US56 x NB1)	23.60	20.80	125	134
4760	YRS (911 x 9717-4)	22.93	19.85	126	119
3763	YRS 8583 mm inbred	18.82	16.86	127	133
0539	NB7	20.25	16.37	125	118
4757A	YRS (911 x 9716-4)	19.63	16.09	127	122
4716-6	YRS (US56 x NB1)	18.32	15.90	135	135
F56-511	NB2	19.61	15.70	118	121
4754A	YRS (671-22 x 9716-10)	18.88	15.54	128	130
4753A	YRS (671 x 9716-4)	17.90	15.46	131	132
F61-562HO	MS of 562	17.94	14.91	129	129
F58-502HO	MS of NB1	18.06	14.90	124	123
4742	YRS (928-9 x 5502)	16.19	14.63	132	129
3740	YRS (928-3 x 5502)	15.56	14.40	120	121
	L.S.D. (5%)	2.47	2.20	Beets per 100' row	

Table 3. Comparison of the root yield of yellows inoculated sugarbeet hybrids with noninoculated checks at Davis, California, in 1965.

Hybrid	Description	Acre Yield Check	Acre Yield Inoc.	Harvest Count Check	Harvest Count Inoc.
		Tons	Tons	Number	Number
413H8	(562H0 x 546) x 13	33.10	30.33	121	134
4716H3	562H0 x 716	32.22	30.28	134	131
F64-30H8	(562H0 x 546) x 30	31.11	28.58	126	134
437H8	(562H0 x 546) x 37	32.64	28.45	140	143
F64-30H4	(562H0 x 569) x 30	30.09	28.10	142	143
413H4	(562H0 x 569) x 13	31.46	27.39	138	134
463H8	(562H0 x 546) x 663	31.57	27.06	142	144
4754H3	562H0 x 754	27.09	26.78	134	139
437H4	(562H0 x 569) x 37	30.53	26.60	142	141
4539H4	(562H0 x 569) x NB7	29.04	25.81	141	147
463H4	(562H0 x 569) x 663	30.39	25.48	142	140
4753H3	562H0 x 753	29.59	25.15	133	135
4757H3	562H0 x 757	28.85	24.74	130	134
F64-569H3	562H0 x 569	20.75	18.31	140	145
	L.S.D. (5%)	3.10	2.41	Beets per 100' row	

Table 4. Gross sugar yields of yellows-resistant hybrids in 1965 California variety tests, expressed in percent of the yield of US H6.

Location	13H4	13H8	30H4	30H8	37H4	37H8
Salinas - Nov.	104	121	106	118	89	98
Salinas - Dec.	110	109	100	102	96	96
King City	116	126	99	109	90	101
San Lucas	114	-	107	111	-	-
Brawley	109	107	97	94	94	102

Table 5. Sucrose percentage of yellows-resistant hybrids in 1965 California variety tests, expressed in percent of the yield of US H6.

Location	13H4	13H8	30H4	30H8	37H4	37H8
Salinas - Nov.	100	101	100	103	98	97
Salinas - Dec.	96	101	99	101	99	100
King City	103	97	98	99	94	88
San Lucas	99	-	99	100	-	-
Brawley	100	97	100	97	100	99

13H4 = (562HO x 569) x 413C
13H8 = (562HO x 546) x 413C
30H4 = (562HO x 569) x 330
30H8 = (562HO x 546) x 330
37H4 = (562HO x 569) x 437
37H8 = (562HO x 546) x 437

Table 6. Comparison of the performance of a hybrid produced with a yellows-resistant pollen parent and US H7 in four 1965 variety tests.

Location	Variety	Acre Yield Sugar	Acre Yield Beets	Sucrose
		Pounds	Tons	Percent
Brawley	413H4	8380	24.60	17.1
	US H7	7160	21.18	17.0
	L.S.D. (5%)	498	1.52	0.47
King City	413H4	6900	24.67	14.0
	US H7	5670	20.38	13.9
	L.S.D. (5%)	766	2.20	0.80
San Lucas	413H4	9580	28.18	17.0
	US H7	8160	24.84	16.4
	L.S.D. (5%)	684	1.84	0.40
Salinas	413H4	11,640	38.07	15.3
	US H7	10,060	32.18	15.7
	L.S.D. (5%)	940	3.65	N.S.

413H4 = (562HO x 569) x 413C
US H7 = (562HO x 569) x 663

Effect of Virus Yellows on Guard Cell Chloroplasts in Sugarbeets

Richard J. Hecker

It is known that beet yellows virus causes a deficiency of chloroplasts in cells along the cleared veins of infected beets and in general, causes a visible disorganization of chloroplasts [Esau (2)]. Esau also noted inclusion bodies in the stomatal guard cells of infected plants.

Since from the breeding standpoint there are no precise selection criteria for resistance to beet yellows virus or beet western yellows virus, the present study was made to examine the relationships of disease, genotype, and stomatal guard cell chloroplast condition and number. It was intended not only as a search for a selection criterion but also to relate chloroplast condition and number to various other characters with the object of shedding additional light on disease characteristics.

Materials and Methods

The experiment was conducted in the greenhouse at Salinas, California, during the winter of 1964-65. It consisted of two populations, three treatments, and ten replications. There were six plants (individual pots) per replication, for a total of 60 plants per population within treatment. The two populations were 413B, which was developed by five cycles of selection for yellows resistance in US 75, and 5511, which was a yellows susceptible selection from the partially inbred NB2. In field tests 413B has shown considerable yellows tolerance (3). The three treatments were: no infection, infected with beet yellows virus (Brawley strain), and a combined infection of beet western yellows virus with an unidentified strain of beet yellows virus.

Six characters were studied:

(1) Chloroplast number per pair of stomatal guard cells,

(2) Chloroplast disorganization score (0 = complete disorganization, 5 = no disorganization),

(3) Yellowing score (0 = all leaves very yellow, necrotic and etched, 5 = no yellowing relative to the noninoculated entry),

(4) Root weight in grams,

(5) Top weight in grams,

(6) Total plant weight in grams.

The experiment was planted November 10, 1964, and inoculated December 8; the yellowing score was made February 15, 1965. Chloroplast number and disorganization score were determined one replication per week starting January 11 (hence replication effect was confounded with growth stage effect for these two characters). Five determinations of chloroplast number were made in each plant. Chloroplasts in the guard cells of the non-infected plants reached their highest degree of organization in the most mature leaves but prior to senescence. Therefore, in determining chloroplast number and condition, the most mature leaves were used for sampling. In making these determinations, a small piece of epidermis was stripped from the dorsal side of the leaf, mounted on a glass slide in a drop of water, covered with a cover glass, and examined under 430X magnification. Using this technique, the chloroplasts in the stomatal guard cells were all visible and easily counted except in those cases where there was a high degree of chloroplast disorganization or degradation.

Root and top weight determinations were made on March 18, but only six replications were used, since it was necessary to save plants in the other four replications as inoculum source plants for other studies.

Results

The means for populations, treatments, and treatments within populations for all six characters are shown in Table 1. Their least significant differences are also included.

The effect of beet yellows infection (Brawley strain) was more severe for every character (although not significantly so in all cases) than the combined infection. The unidentified strain of beet yellows virus in the combined infection was undoubtedly less virulent than the Brawley strain of beet yellows virus. Hence the combined infection was not as damaging as the Brawley strain by itself.

Under conditions of this experiment, the number of chloroplasts per pair of guard cells appeared to be little influenced by the virus infection. There was, however, a difference between populations and a significant population by treatment interaction. Hence genotype is the principal determinant of chloroplast number.

In the case of chloroplast condition populations, treatments, and their interaction were all significant, with treatments having the greatest effect. The significant interaction results from the fact that chloroplast condition was not affected by treatment in 413B but was affected in 5511. Therefore, yellows virus infection results in more or earlier guard cell chloroplast disorganization in susceptible genotypes than in more tolerant or resistant genotypes.

A significant amount of yellowing resulted from infection; also, infected plants of 5511 were considerably more yellow than those of 413B.

Table 1. Means and least significant differences for the six characters of interest.

Population and/or treatment	Chloroplast number	Chloroplast condition	Yellowing score	Root weight (gm.)	Top weight (gm.)	Total weight (gm.)
413B	15.24	2.98	4.59	60.4	39.6	100.0
5511	14.92	2.56	3.74	31.8	36.2	68.0
$LSD_{0.05}$	0.27	0.23	0.13	3.6	2.7	5.3
BYV	14.99	2.49	3.44	36.8	33.4	70.2
BYV & BWYV	15.20	2.77	4.07	42.6	37.7	80.3
Check	15.06	3.06	5.00	58.9	42.6	101.5
$LSD_{0.05}$	0.33	0.29	0.16	4.4	3.3	6.5
413B						
BYV	14.65	2.88	4.38	57.2	39.3	96.5
BYV & BWYV	15.54	3.03	4.40	54.5	39.3	93.8
Check	15.54	3.03	5.00	69.5	40.1	109.6
$LSD_{0.05}$	0.47	0.40	0.23	6.3	4.5	9.2
5511						
BYV	15.34	2.10	2.50	16.4	27.5	43.9
BYV & BWYV	14.85	2.50	3.73	30.7	36.1	66.8
Check	14.59	3.08	5.00	48.3	45.1	93.4
$LSD_{0.05}$	0.47	0.40	0.23	6.3	4.6	9.2

The interaction of treatment and genotype indicates that the yellowing caused by a particular virus or strain is partially dependent on the genotype of its host.

Root weight reductions due to infection were significant in both populations--but particularly drastic in 5511 where the Brawley strain of beet yellows virus reduced root yield 66 percent. The mixed infection caused a 36 percent reduction. In 413B the yield losses due to infection were not different for the two treatments but were 18 and 22 percent relative to the check. Top weight of 413B was unaffected by infection, but there was a significant reduction in 5511 (39 and 20 percent relative to the check). Total weights followed the pattern of root weights with significant reductions due to infection in both populations.

Simple correlation coefficients based on population means within treatments are shown in Table 2. Yellowing score is positively correlated with chloroplast condition, root weight, and top weight. Chloroplast condition is positively correlated with root and top weight. These correlations resulted from the fact that yellows-free beets were heavier, greener, and had a higher degree of chloroplast organization. Chloroplast number was not significantly correlated with any of the other characters.

Table 2. Simple correlation coefficients calculated from treatment means within populations.

Character	Chloroplast condition	Chloroplast number	Root weight	Top weight
Yellowing score	0.975**	-0.146	0.902*	0.959**
Chloroplast condition		-0.119	0.895*	0.952**
Chloroplast number			0.114	-0.347
Root weight				0.761

No cell inclusions, as described by Esau (2), were observed in the guard cells or other epidermal cells. This does not exclude the possibility that inclusions might be observed, using certain staining techniques.

Discussion

In this experiment the number of chloroplasts in the stomatal guard cells was unaffected by disease treatment but was genotype dependent. Neither was it significantly correlated with any other character. Hence this character would seem to offer no promise as a selection tool or measure of disease resistance.

The degree of chloroplast disorganization was affected by disease treatment, genotype, and a treatment by genotype interaction. This genotype and interaction effect, together with the fact that degree of disorganization is a rather poorly defined index, indicates that it would be of little practical value in individual plant selection.

Yellowing score relative to the check appears to be genetically conditioned and correlated with root yield. However, McFarlane and Bennett (3) have shown in extensive field tests with diverse genotypes that there is little correlation between yellowing and yield reduction due to yellows infection.

Yield reductions of both root and top were affected by both treatment and genotype. 413B shows considerable disease tolerance relative to 5511. The correlation of root and top yield with yellowing and chloroplast condition is expected from examination of the means and is a logical relationship. Yellowing and chloroplast degradation would be expected to depress photosynthesis and, hence, plant yield. The reason for chloroplast degradation may be, as Bawden (1) suggests, that cells from plants infected with yellows type viruses contain more starch than normal and chloroplasts may be so gorged with starch that they burst.

Among the six characters, comparative root yield appears to be the most reliable indicator of disease resistance. However, even this character leaves much to be desired as a selection criterion when selection is being made on an individual plant basis.

Summary

A greenhouse test of two populations inoculated with beet yellows and beet western yellows virus showed that the number of chloroplasts in the stomatal guard cells was unaffected by disease treatment. The degree of chloroplast disorganization and yellowing of the leaves are related to treatment, but neither appears to be of much value in making individual plant selections. Root and top yields are related to yellowing and chloroplast condition and are affected by treatment. None of the six characters studied provides a completely reliable index or measure of disease resistance, but among them, comparative root yield is likely to be best.

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PERFORMANCE OF FIRST AND SECOND SUCCESSIVE SUGAR BEET SELECTIONS MADE ON THE BASIS OF THE AMINO ACID PATTERN IN THE MATURE LEAVES OF INFECTED PLANTS

By

J. M. Fife

Introduction

The results of 5 years of testing have shown that certain sugar beet selections, made on the basis of the amino acid pattern in the mature leaves of beet yellows infected plants, were superior to the parent in yield of beets, percent sucrose and sugar per acre. The object of the 1965 test was to compare the performance of 3 of the most promising first selections and 3 of the most promising second successive selections with the parent (US 75) when the plants were inoculated with a more virulent strain of the beet yellows virus than strain 5 which was used for all previous field tests. The "Brawley strain" was used in the test reported here. This strain of the beet yellows virus has been shown by Bennett to be more virulent than strain 5.

Methods

The test was carried out in a plot adjoining a test conducted by McFarlane, Bennett, and Skoyen. All agronomic practices were the same. The information pertinent to this test is as follows:

Location: Spence Field of the U. S. Agricultural Research Station.

Fertilizer applied: 400 lbs. of 10-10-5 rototilled into the beds immediately preceding the final shaping.

Planting date: April 29. Plants thinned, May 28.

Disease treatment: Plants inoculated June 21 (41 days after emergence) with the Brawley strain of the beet yellows virus.

Harvest date: October 19. Growing period, 160 days from emergence.

Diseases: By thinning, practically all the plants showed symptoms of yellows. Strains of western yellows may have predominated but due to the presence of sugar beet plants growing in the field at the time of emergence, the seedlings could have been infected with strains of beet yellows virus as well.

Insects: Insects were controlled by an effective spray program.

Experimental design: 7 X 7 latin square, two-row plots 50 feet long.

Sugar analysis: From two 18-beet samples taken from each plot.

Results

The performance of all selections was superior to that of the parent despite the fact that the plants were inoculated with a more virulent strain of the beet yellows virus (Brawley strain) than was used to inoculate the plants in the previous tests (table 1).

Table 1.

Test comparing first selections and a second successive selection with US 75, in which all plants were inoculated with a virulent strain of the beet yellows virus 41 days after emergence.

Basic Code & Selection		Seed Increase	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
US 75	(parent)		2,525	9.1	13.8	127
DS3	1st	3rd	3,205**	10.5**	15.2**	126
DS323	1st	2nd	2,680	9.4	14.3*	130
DS23	1st	3rd	3,036**	10.3**	14.8**	128
RS3	2nd Suc.	4th	3,616**	11.6**	15.5**	136
RS10	2nd Suc.	4th	2,976*	10.2*	14.6**	128
RSC-C	2nd Suc.	4th	3,560**	12.0**	14.9**	128
General MEAN			3,085	10.45	14.7	129
S. E. of MEAN			119	0.36	0.17	
L.S.D.	(19:1)		342	1.03	0.49	
	(99:1)		460	1.39	0.67	
S. E. of MEAN in % of MEAN			3.9	3.4	1.2	

Odds 19:1 = 2.030 x $\sqrt{2}$ x Standard Error of MEAN

99:1 = 2.724 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Sugar Pounds	Tons Beets	Percent Sucrose
Between Selections	6	1,181,527	7.72	2.15
Between Replications	6	204,684	1.43	.54
Remainder (Error)	36	99,838	.91	.21
Total	48			
Calculated F values for selections		11.83**	8.48**	10.75**

** Exceeds the 1% point of significance (F=3.35)

* Exceeds the 5% point of significance (F=2.36)

The most striking performance of the selections was their superior percentage sucrose compared to that of the parent. The mean percent sucrose for the 6 selections was 14.9. This value is 1.1 percentage points higher than the percent sucrose in the roots of the parent. Five of the 6 sugar beet selections produced significantly more tons of beets, and sugar per acre, than was produced by the parent.

Correlation between resistance to beet yellows
and the amino acid ratio

Three years of replicated field tests have been conducted in which the performance of a first selection, a second successive selection and the parent (US 75) are correlated with their amino acid ratios. The amino acid ratios of these selections and the parent were determined in the same test, in the mature leaves of beet yellows-inoculated plants grown in the greenhouse in sand culture under controlled nutritional conditions. The amino acid ratio was determined on 25 individual plants of each selection and the parent. Mean values were used for correlation purposes. The correlation between the amino acid ratio of the selections and yield of beets and of sugar per acre are shown in figures 1 and 2.

The correlation coefficient "r", between the amino acid ratio and the yield of beets (and also sugar per acre) is positive and highly significant.

Figure 1.

CORRELATION BETWEEN THE AMINO ACID RATIO AND YIELD OF BEETS FOR FIRST AND SECOND SUCCESSIVE SELECTIONS IN RELATION TO THE PARENT (US 75)

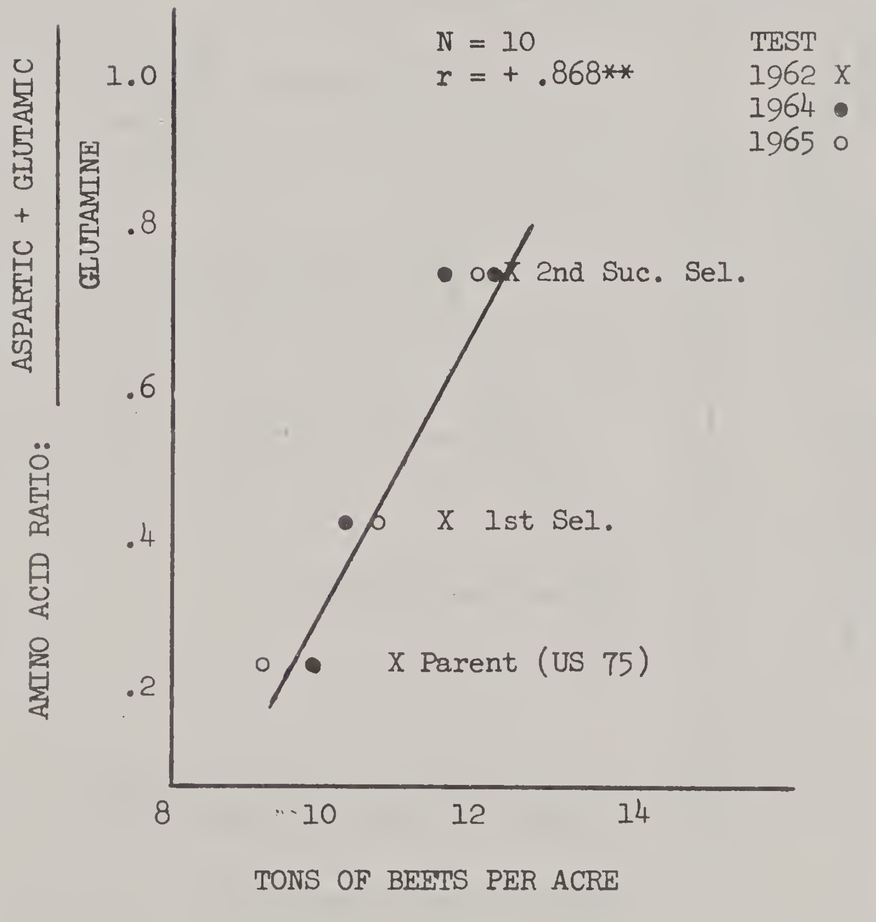
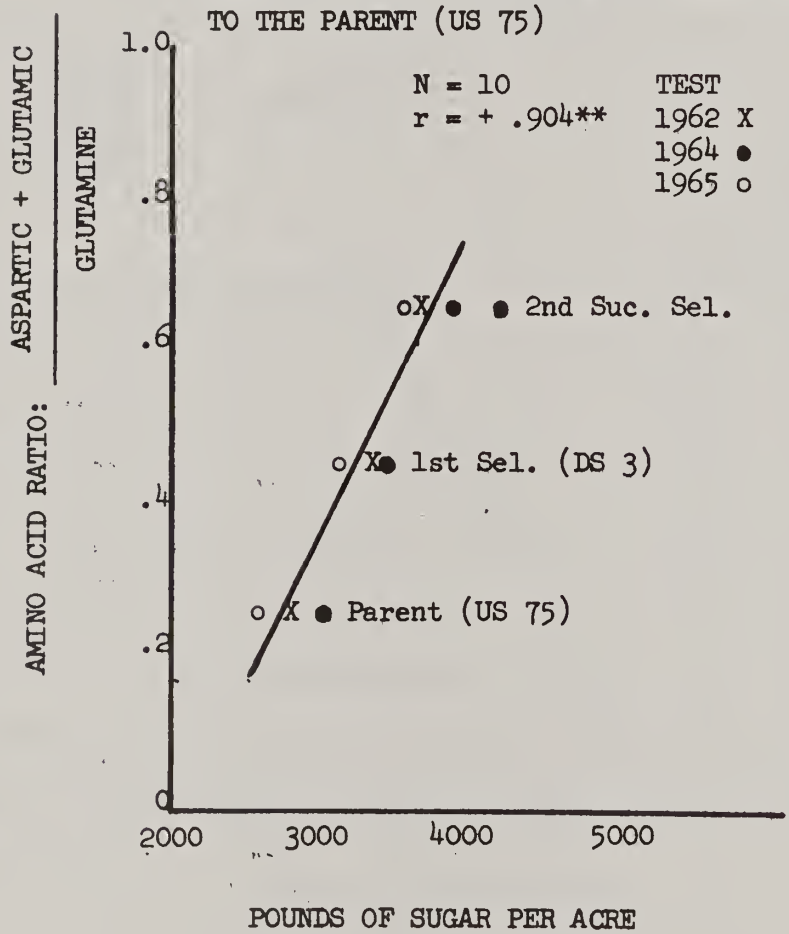


Figure 2.

CORRELATION BETWEEN THE AMINO ACID RATIO AND YIELD OF SUGAR PER ACRE FOR FIRST AND SUCCESSIVE SELECTIONS IN RELATION TO THE PARENT (US 75)



Summary

Certain sugar beet selections, made on the basis of the amino acid pattern in the mature leaves of beet plants infected with beet yellows, have consistently produced higher yields of beets and a higher percentage sucrose in roots of the selections than in roots of the parent (US 75). The correlation coefficient "r", between the amino acid ratio (concentration of $\frac{\text{aspartic acid + glutamic acid}}{\text{glutamine}}$) and the yield of beets and the yield of sugar per acre, was positive and significant.

Acknowledgements

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P A R T IV

BREEDING FOR NEMATODE RESISTANCE

- - - - -

METHODS OF SCREENING FOR RESISTANCE

D. L. Doney

E. D. Whitney

Progress Report on the Evaluation of Sugarbeet Breeding Lines Selected for Nematode Resistance and of the Screening Method used in Making these Selections

ELVIN D. WHITNEY & DEVON L. DONEY

INTRODUCTION

By selecting within varieties and lines of Beta vulgaris L. for tolerance to the sugarbeet nematode Heterodera schactii Schm. in combination with root-rotting fungi, Charles Price has produced selections that consistently yield significantly better than the standard varieties US 41 and US 75. The procedure used in screening for resistance in the greenhouse was described in the 1960 Sugar Beet Research Report, pages 91 and 92. However, an evaluation of the efficiency of this screening procedure in producing sugarbeet lines tolerant to the sugarbeet nematode, root-rotting fungi and the two in combination has not been reported. The object of these tests was to further evaluate promising sugarbeet selections for resistance and attempt to evaluate the present screening system in producing lines tolerant to the nematode, root-rotting fungi and the two in combination.

MATERIALS AND METHODS

Twenty-four of the most promising lines were selected for the test based on their performance in the 1964 greenhouse test and field tests for 1960-63. Also included for testing were 4 monogerm selections; 338, 339, SL9229 and F_2-067. Varieties US 41 and US 75 were used as checks. These 30 selections were planted in the nematode field plot at the U.S. Agricultural Research Station, Salinas, California, in a randomized complete block design of 6 replications each. Plots were 25 feet long and plants thinned to an 8-to 10-inch spacing 4 weeks after planting. Prior to planting, soil samples were systematically taken from the plot to determine the distribution of cysts in the soil. The results of the cyst count were analyzed as a Latin square.

These 30 selections were also planted in flats of soil in the greenhouse for screening. Two soils were selected. One of the "field soils" had been used for the winter-greenhouse test and had been collected from a field with plants showing nematode damage. This soil wäs known to be heavily infested with root-rotting fungi. The second soil, "plot soil", was soil collected from the Station field plot prior to planting. These 2 soils were mixed (2 parts nematode-infested soil, 1 part sand, and 1 part silt) following established procedures. Each soil was sampled and processed to determine the number of nematode cysts containing eggs per 100 grams of soil. Three flats of 48 plants per flat of each selection were transplanted in each soil. After a two-month growing period, the living plants in each flat were washed free of soil and the

roots individually rated for vigor, based on a scale of I to V (I = very vigorous; V = dead). The 10 most vigorous beets from each flat were transplanted individually to their respective infested soil mixture in an aluminum cylinder and grown for an additional 2 months. At the end of this growing period, each beet was again rated and the total root weight taken for each replication (10 plants). The mean rating for each selection was obtained by multiplying the rating by the number of beets in each category, summing, and taking the mean of the 3 replications. Therefore, the smaller the mean rating, the higher the resistance of the selection.

The soil from one cylinder per selection for each soil was processed to determine the number of cysts per 100 grams of soil.

The field experiment was harvested after a growing period of approximately 150 days. Root yields and sucrose determinations were obtained for each replication. The sucrose sample was obtained from all the beets in a replication.

The yield means were adjusted on the basis of nematode population due to a two-way gradient in cyst population. This adjustment was based on the regression of the nematode population with yield.

RESULTS AND DISCUSSION

The results of these tests are found in Tables I and II. In the field trial, US 41 gave very poor yields in relation to the other selections; in fact, about three fourths of the selections significantly outyielded US 41. However, US 75 gave a somewhat better yield with only one selection (134-H8) yielding significantly higher.

When adjustment was made for nematode population, US 41 and US 75 yielded equally well, with only 6 selections significantly outyielding these 2 varieties. It is noteworthy to observe that 4 of these 6 were the better selections before adjustment. Differences were also observed between selections for sucrose percentage.

A correlation of r = .92 was obtained between yield and nematode population. A correlation (r = .72) was also obtained between yield and number of beets dying between thinning and harvest. Nematodes are not believed to be responsible for the killing of beets; however, they can predispose plants to infection by other pathogens. This appears to be what is happening in this case.

TABLE I FIELD DATA

Variety or Line	Selection from	Acre Root Yield Actual Tons	Acre Root Yield Adjusted Tons	Sucrose Percent	Beets per 100 ft. row
134-H8	S2	8.91	10.67	13.0	129
067-7	US 33	8.65	3.61	13.5	121
159-8	US 33	8.27	11.60	14.3	129
054-1	S2	8.27	11.08	13.1	125
C057-15	US 56	8.14	4.25	13.8	136
F_2-067	SLC15 x 56-408	7.72	1.39	13.5	135
861-15	US 33	7.35	10.69	14.9	113
063	US 22	7.22	8.38	12.9	109
019	US 400	6.64	8.38	11.8	127
156-22	S2	6.64	6.83	12.4	116
050-6	S2	6.53	5.68	13.4	126
033-1	Am. Crystal 56-408	6.49	6.16	12.8	135
101-7	US 33	6.34	2.45	13.2	116
306	Am. Crystal 58-607	6.34	9.14	14.2	124
162-15	US 22	6.31	2.85	13.3	126
US 75		6.29	4.66	13.3	124
899-11	US 22	6.03	5.18	13.1	119
060-3	US 33	5.97	5.64	14.2	123
0317	Am. Crystal 58-408	5.97	7.73	12.8	111
280-23	S2	5.74	7.25	13.8	117
257-5	US 56	5.61	.59	13.4	130
861-8	US 33	5.43	10.80	14.4	120
228-B1	US 41	4.86	10.49	12.8	117
863	US 22	4.77	2.35	13.1	120
102-23	US 33	4.09	7.42	13.3	117
157-D3	US 56	3.70	7.45	13.1	121
338	Monogerm	2.70	2.74	12.3	99
SL9229	Monogerm	2.59	0.00	13.2	110
US 41		2.48	4.61	12.6	107
339	Monogerm	2.13	4.42	13.5	108
		LSD .05 2.6	LSD .05 4.0	LSD .05 1.1	

GREENHOUSE TESTS

When this trial was started, the field soil had significantly more cysts containing eggs than the plot soil (28.5 to 20.4 per 100 grams of soil respectively). However, after harvest the nematode populations were reversed; i.e., the plot soil had significantly more cysts containing eggs than the field soil (183.2 to 123.00 cysts per 100 grams of soil, respectively). In other words, a larger nematode population had built up in the soil with the smaller infestation of root-rotting fungi (plot soil).

There were no significant differences between varieties for root weight for either soil. However, the difference due to soil was highly significant, with plants grown in plot soil giving higher yields. The 40% difference in yield is undoubtedly the result of fungi, as the increase in number of nematode cysts was greater in the soil with the higher yield, indicating the loss due to fungi was even greater. This loss was in part due to the difference in the number of beets dead at the end of the growing period in the soil-filled cylinders. In the field soil, 16.8% of the plants were dead; while in the plot soil, only .8% of the plants had died. This would indicate that death was due to fungi and not nematodes. This same trend existed for plants growing in flats of soil; i.e., 8.6% dead plants in the plot soil and 15.3% in the field soil.

There were also no significant differences in resistance ratings between varieties grown in either soil. But, here again, plants grown in plot soil gave a significantly better rating than plants grown in field soil. A comparison was also made between the ratings of the first and second screenings. If progress is being achieved by this technique, one would expect a better rating for the second screening. A significantly better rating was observed in the second screening for plants grown in plot soil, but there was no significant difference between screenings for plants grown in field soil.

These results confirm the fact that progress has been made. However, these results indicate that heavy soil infestation of root-rotting fungi are confounding the results of the present technique. Work is underway to isolate the various pathogens involved and determine their relative importance, as well as to obtain nematodes free of other pathogens, so that more precise screening techniques can be developed and used.

TABLE II GREENHOUSE DATA

Variety or Line	Mean Resistance Rating				Mean Root Weight	
	Plot Soil		Field Soil		Plot Soil	Field Soil
	Flats	Cylinders	Flats	Cylinders	Grams	Grams
134-H8	3.43	2.50	3.73	3.63	152.5	67.0
067-7	3.48	2.73	3.64	3.73	121.5	59.3
159-8	3.48	2.83	3.70	3.40	123.2	94.1
054-1	3.46	3.17	3.65	3.13	133.8	87.5
C057-15	3.51	3.07	3.65	3.70	95.2	87.0
F_2-067	3.41	2.03	3.68	4.10	144.7	47.2
861-15	3.51	3.00	3.69	3.50	105.8	76.3
063	3.51	2.43	3.52	3.27	104.7	89.7
019	3.49	2.57	3.62	3.27	119.8	68.3
156-22	3.42	3.03	3.68	3.43	136.0	65.2
050-6	3.36	1.90	3.76	3.70	154.8	61.0
033-1	3.56	2.93	3.79	3.57	112.3	76.3
101-7	3.34	2.53	3.67	3.67	177.6	72.8
306	3.39	2.50	3.61	3.70	119.7	50.3
162-15	3.45	2.93	3.63	3.30	107.2	67.7
US 75	3.48	2.30	3.64	3.87	145.7	63.2
899-11	3.51	2.87	3.70	3.43	115.2	80.8
060-3	3.43	3.00	3.63	3.47	116.3	73.8
0317	3.52	2.43	3.63	3.53	129.0	82.7
280-23	3.61	2.37	3.87	3.50	95.7	64.2
257-5	3.42	2.87	3.69	3.40	113.3	62.0
861-8	3.38	2.63	3.53	3.33	124.0	74.5
228-B1	3.45	2.60	3.55	3.36	144.8	77.2
863	3.56	2.67	3.74	3.73	108.7	78.8
102-23	3.54	2.93	3.64	3.33	109.0	77.5
157-D3	3.46	2.63	3.54	3.07	108.5	85.8
338	3.39	2.57	3.69	4.10	120.3	43.8
SL9229	3.51	2.60	3.68	3.43	111.2	76.5
US 41	3.46	2.86	3.69	3.87	97.2	81.2
339	3.46	3.27	3.84	3.70	85.3	68.0
Mean	3.47	2.69	3.67	3.54	121.1	72.0

Analysis of Variance for Root Ratings from Greenhouse Tests.

Source of Variation	df	SS	MS	F
Reps	2	0.3172	0.1586	
Soils	1	24.4453	24.4453	46.58*
Error (a)	2	1.0493	.5247	
Tests	1	18.8742	18.8742	130.50**
Soils x tests	1	9.0853	9.0853	62.83**
Selections	29	2.9801	.1028	.71
Soils x sel.	29	5.5266	.1906	1.32
Tests x sel.	29	2.0358	.0702	.48
Soils x tests x sel.	29	4.3192	.1489	1.03
Error (b)	236	34.1360	.1446	
Total	359	102.7689		

* = Significant at P = .05
** = Significant at P = .01

Analysis of Variance of Root Weights from Greenhouse Tests.

Source of Variation	df	SS	MS	F
Reps	2	104,165.25	57,082.62	
Soils	1	108,461.90	108,461.90	39.73*
Error (a)	2	5,459.61	2,729.80	
Varieties	29	19,324.20	666.35	0.89
Soils x var.	29	30,177.49	1,040.60	1.40
Error (b)	116	86,017.30	741.53	
Total	179	353,605.75		

* = Significant at P = .05

P A R T V

INTERSPECIFIC HYBRIDIZATION

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STUDIES ON TETRAPLOIDY

Helen Savitsky V. F. Savitsky

The research was supported in part by funds provided through the Beet Sugar Development Foundation (Project 11).

STUDIES IN POLYPLOIDY

Helen Savitsky

PRODUCTION OF TETRAPLOID STRAINS

1. C_o tetraploid plants were selected in 1964 in 2 inbred lines (one of these lines is leaf spot resistant), and in a multigerm population which is high in combining ability. Seeds obtained from C_o plants were planted in the fall of 1964 and chromosome number was determined in the young C_1 plants during winter of 1965. The C_1 tetraploid plants were selected and propagated on isolations in 1965.

2. Seeds of the monogerm leaf spot resistant inbreds and of a high in sucrose multigerm population were treated by colchicine in 1964. C_o seedlings affected by colchicine have been exposed to thermal induction and the plants were later examined for the size of pollen grains. The tetraploid C_o plants with large (diploid) pollen grains were selected and intercrossed within the lines. A total of 278 C_o plants were examined for the size of pollen grains. Seeds obtained from the selected C_o plants were planted for determination of chromosome number and selection of the C_1 tetraploid plants.

A STUDY OF VIABILITY OF DIPLOID, TRIPLOID,AND TETRAPLOID SUGARBEET SEEDS

A commercial use of polyploid varieties requires a high quality of sugarbeet seeds. Because of some indications on the lower germination ability of triploid and tetraploid sugarbeet seeds, a detailed study of seed development at different ploidy levels is necessary. Both environment and genetic factors may influence the viability of seeds. The purpose of this study is the investigation of the process of development of diploid, triploid, and tetraploid embryos and seeds, as well as obtaining information to which extent the viability of seeds is influenced by different ploidy levels.

Materials and Methods

1. The monogerm hybrid diploid, triploid and tetraploid sugarbeet seeds were obtained by open pollination of the diploid and tetraploid male-sterile monogerm lines by the diploid and tetraploid populations. The male-sterile monogerm lines: SLC 2n 91, Utah-Idaho 2n 129, Beltsville 2n 66, Salinas 2n 562-H, and SLC 4n 91 were pollinated on separate isolations by the diploid and tetraploid multigerm and monogerm populations.

2. Diploid and tetraploid seeds were also obtained after open pollination of diploid and tetraploid monogerm and multigerm populations used as pollinators.

The following methods of investigation are applied:

a/ A study of meiosis and gamete formation in tetraploid populations to find out whether the gametes with deviating chromosome number may decrease the viability of seeds derived from pollination by tetraploids. Buds of corresponding stages were fixed for cytological study.

b/ Examination of ovules for determination of percent of non-fertilized, fertilized normally developed ovules, and fertilized but aborted ovules in different crosses. Branches were collected from male-sterile plants and from the plants in the populations of pollinators. Development of ovules in the diploid, triploid and tetraploid matings was analyzed.

c/ A study of germination of fruits harvested from the plants in which the development of ovules was analyzed.

d/ An embryological study of diploid, triploid, and tetraploid seeds to observe whether some deviations from the normal outline of fertilization, or deviations in embryos and seed development may occur at different ploidy levels. Deviations which might influence the viability of seed. Material for embryological study of diploid, triploid and tetraploid seeds was collected and fixed.

Results of this study will be given in the next year report.

INTERSPECIFIC HYBRIDIZATION

VULGARES-PATELLARES HYBRIDS

Helen Savitsky

A STUDY OF TRANSMISSION OF CHARACTERS FROM *PATELLARES* SPECIES TO THE SPECIES *B. VULGARIS*

1. A STUDY OF TRANSMISSION OF RESISTANCE TO SUGARBEET NEMATODE (*HETERODERA SCHACHTII*)

The new crosses between *B. vulgaris* and the species of the section *Patellares* are continuously made and the viable F_1 hybrids propagated by grafting to maintain the basic group of F_1 hybrids.

A cytological study of the hybrids and growing of the next hybrid generations is being continued.

The first backcross hybrids, second backcross hybrids, and F_2 hybrids were exposed to selection for sugarbeet nematode. F_2 and b_2 seeds, obtained from b_1 plants selected for nematode resistance, were planted and the seedlings grown of them tested in nematode infested soil. The technic of plant infestation was changed in 1965. The soil mixture was adjusted so that hybrids were exposed to twice the nematode cysts used in the previous tests. As before, the plants selected in the first test were submitted to 2 additional tests. But for the latter tests to the pots containing nematode infested soil, 14 viable cysts were added for each plant tested to insure infestation.

Total 1800 plants were tested for resistance in 1965. The plants selected were distributed into 2 groups: the first group consisted of plants having 0 to 5 female nematodes on the roots, the second group contained plants on the roots of which from 5 to 10 females were observed. Some plants which were selected for nematode resistance developed tumors on the roots and on the leaf blades. Plants with few female nematodes on the roots (0-10) were selected in all hybrid generations (b_1, b_2 and F_2). The most promising 12 plants were selected from one segregating F_2 line. Six of these 12 plants remained free of nematodes in 3 tests; on the other 6 plants 2 or 3 females were observed on the roots. All plants in this group have a peculiar phenotype: they develop long hanging down petiols and narrow, elongated leaves. Five of 12 plants developed tumors on the leaf blades.

All plants selected for nematode resistance will be grown and exposed to thermal induction to obtain seeds of the next generations for further study and selection for resistance.

2. A STUDY OF TRANSMISSION OF MONOGERM CHARACTER FROM THE *PATELLARES* SPECIES

Species of the section *Patellares* Tr. - *Beta patellaris* Moq., *Beta procumbens* Chr. Sm., and *Beta webbiana* Moq. produce monogerm seeds. The idea of the possibility of transmission of the monogerm character from *Patellares* species is widespread. Even an indication about the origin of the American monogerm sugarbeets from *B. procumbens* is cited in the East German literature.

An embryological study of the development of inflorescence and fruit in different *Beta* species previously performed by the author suggests that *Patellares* species cannot be considered as a source of transmission of monogerm character. The mode of development of the monogerm fruit in the section *Patellares* differs from the development of monogerm fruit in the section *Vulgares* Tr. (sugarbeets) and in the section *Corollinae* Tr. (*B. lomatogona* Fish. and Mey).

In the inflorescence of the multigerm sugarbeet races several receptacles develop on a common peduncle. Each receptacle produces a flower.

All flowers are joined by the tissue of the same peduncle. The lower bases of the ovaries together with contained ovules are imbedded in the tissue of the peduncle. Only the upper parts of the flowers, beginning from the base of the sepals grow over the peduncle. The inflorescence is compound, multifloral and the fruit developed is also compound (a multigerm seedball). (Fig. 1).

In the monogerm races of B. vulgaris (sugarbeets) only one receptacle and consequently only one flower develops on the peduncle. The inflorescence is simple and the fruit also simple and monogerm.

In Patellares species the type of development of the inflorescence is similar to that of the multigerm races of B. vulgaris. Several receptacles and several flowers develop on the common peduncle, but every flower develops its own pedicel. The pedicels of all flowers in an inflorescence are joined at their bases, thus forming a compound multifloral inflorescence. However, the fruits are not embedded in the common pericarp, they grow separately on the pedicels. After the pedicels dry and break, the monogerm fruits are released. Fruit in Patellares species is simple and monogerm.

The possibility of transmission of monogerm character from Patellares species was studied in the hybrids between B. vulgaris and species of the section Patellares.

Materials and Methods

F_1 hybrids between multigerm sugarbeets and Patellares species always developed a multifloral inflorescence and multigerm fruits. Therefore, in the given experiment only monogerm sugarbeet races, homozygous for the recessive gene m, which determines the monogerm character, were used as a female parent. The populations of the monogerm B. vulgaris races, of B. patellaris, and of diploid hybrids (2n B. vulgaris x 2n B. procumbens), triploid hybrids (4n B. vulgaris x 2n B. procumbens) and of tetraploid hybrids (4n B. vulgaris x 4n B. patellaris) were studied.

Five hybrid matings were studied at each ploidy level. In each mating, 1 plant was examined (5 plants for each ploidy level). Five monogerm B. vulgaris and 5 B. patellaris plants were also examined. The number of flowers was determined in 100 inflorescence units in each plant (2 reps.: 50 inflorescence units from one branch and 50 from another). Total 500 inflorescence units were examined in each population studied.

The data obtained were calculated statistically by using the analysis of variance.

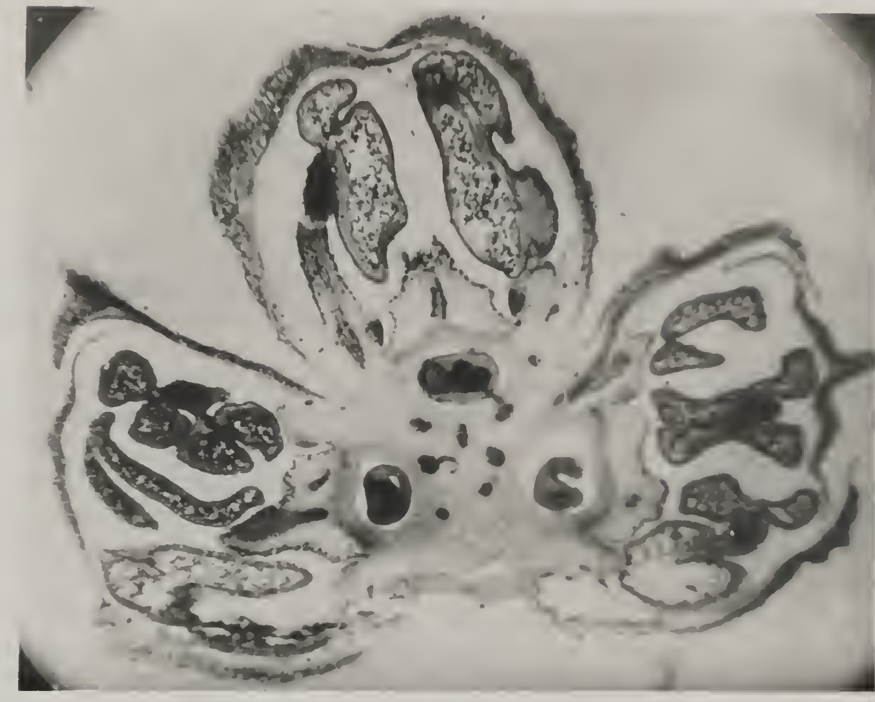

Fig.1. Inflorescence of a multigerm sugarbeet. All ovaries with contained ovules are embedded in the tissue of the peduncle. X 22.

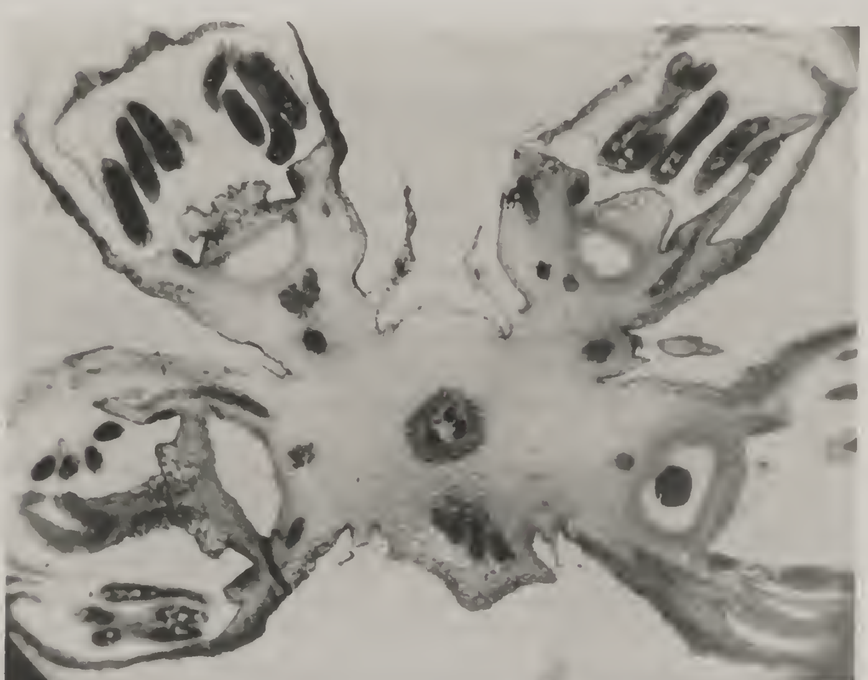

Fig.2. Inflorescence of F_1 Vulgares-Patellares hybrid. The bases of individual flowers are joined by the tissue of the peduncle,but the ovaries with contained ovules are not connected together. X 22.

Experimental Results

In the population of monogerm B. vulgaris (sugarbeets) the mean number of flowers per inflorescence unit was 1.01; and in the population of B. patellaris, 3.80 (Table 1).

All F_1 hybrid populations regardless whether they were diploid, triploid, or tetraploid developed multifloral inflorescence. Mean number of flowers per inflorescence unit varied from 3.73 in the diploid hybrids, to 3.89 in the triploid hybrids and to 3.77 in the tetraploid hybrids. There was no siginificant difference in the number of flowers per inflorescence unit among all F_1 hybrid populations. F calculated for the 2n, 3n, and 4n hybrids equaled 1.3, whereas F tabulated was 19.00 at 5% point and 99.01 at 1% point. But when the data for all populations were compared (B. vulgaris monogerm, B. patellaris and 3 hybrid populations), the difference in variability between populations was highly significant. This variability was contributed by the monogerm population. F calculated was 81.9 and greatly exceeded the F tabulated, which equaled 6.39 at 5% and 15.98 at 1%.

Difference between replications calculated for 5 populations was insignificant F = 1.1, while F tabulated at 5% point was 7.71 and at 1% 21.20.

The interaction population x replication was also insignificant. F calculated for 5 populations was less than 1.

T-test for significance of difference between 5 populations indicated that the only significant difference in the number of flowers per inflorescence unit was observed between monogerm B. vulgaris and all other populations (B. patellaris and 3 hybrid populations). T calculated was 20.549 and T tabulated 2.101 at 0.05, and 2.878 at 0.01. There was no significant difference between diploid, triploid and tetraploid hybrid populations and between hybrid populations and population of B. patellaris (Table 2).

An anatomical study of the multifloral inflorescence in F_1 Vulgares-Patellares hybrids showed that only the bases of the individual flowers were joined by the tissue of the common peduncle. The major part of the flowers grew over the peduncle. The ovaries of the individual flowers, together with the contained ovules, are not connected together. For this reason the individual fruits in a multigerm fruit of F_1 hybrids are joined only at their bases, but are not embedded in the common pericarp and may be comparatively easy separated from each other (Figure 2).

Table 1 ... Average number of flowers per inflorescence unit in B. vulgaris (monogerm), B. patellaris, and in diploid, triploid and tetraploid F_1 Vulgares-Patellares hybrids

Plant N	B. vulgaris monogerm	B. patellaris	$2n$ F_1 hybrids (2n B. vulgaris x 2n B. procumbens)	$3n$ F_1 hybrids (4n B. vulgaris x 2n B. procumbens)	$4n$ F_1 hybrids (4n B. vulgaris x 4n B. patellaris	F calculated for 2n, 3n and 4n F_1 hybrids	F tabulated 5%	F tabulated 1%	F calculated for 2 parental and 3 hybrid populations	F tabulated 5%	F tabulated 1%
	number	number	number	number	number	1.3	19.00	99.01	51.9	6.39	15.98
1	1.01	2.98	4.45	4.29	4.25						
2	1.00	3.83	3.59	4.34	3.49						
3	1.03	4.40	4.35	4.47	3.69						
4	1.01	3.90	3.25	3.15	2.85						
5	1.00	3.90	3.01	3.20	3.59						
Mean	1.01±0.005	3.80±0.170	3.73±0.201	3.89±0.199	3.77±0.190						

Table 2 ... Difference in the average number of flowers per inflorescence unit between populations

Difference between following populations		t calculated	t tabulated 0.05	0.01
2n and 3n F_1 hybrids	0.16	0.799	2.101	2.878
3n and 4n F_1 hybrids	0.12	0.617	2.101	2.878
4n F_1 hybrids and B. patellaris	0.03	0.176	2.101	2.878
4n F_1 hybrids and B. vulgaris monogerm	2.76	20.549*	2.101	2.878

Discussion and Conclusions

In the species B. vulgaris, the type of inflorescence and fruit is controlled by the allel Mm. The recessive gene m is responsible for the development of a simple inflorescence and consequently for the production of monogerm fruit. Monogerm sugarbeet races are homozygous for the recessive gene m. Hybridization of two monogerm plants produces monogerm F_1 progeny. In the monogerm x multigerm matings, F_1 hybrids are multigerm.

Inflorescence in the F_1 hybrids derived from crosses of monogerm sugarbeets x Patellares species was similar to the inflorescence in F_1 hybrids between monogerm and multigerm races of B. vulgaris. All diploid, triploid, and tetraploid interspecific F_1 hybrids developed a compound multifloral inflorescence and produced multigerm fruits. They proved conclusively that the species of Patellares section did not carry the gene for the monogerm trait.

Whether the gene M, or some other gene, is responsible for the formation of a multifloral inflorescence in Patellares species, the genetic nature of these species is similar to the multigerm races of B. vulgaris. The multifloral inflorescence of Patellares species which produces monogerm fruits on pedicels should be considered as only a kind of variation of the multifloral inflorescence.

As in the F_1 Mm hybrids within B. vulgaris, the multigerm character was dominant also in the interspecific Vulgares-Patellares hybrids. Even the triploid F_1 hybrids with two genes m and one gene M were multigerm. The monogerm character cannot be transmitted from Patellares species; nevertheless, the monogerm fruits are produced.

VULGARIS-COROLLIFLORA HYBRIDS

Helen Savitsky, V. F. Savitsky, C. W. Bennett

Species of the section Corollinae Tr. are immune or highly resistant to curly top. To study the possibility of transmission of resistance to curly top from wild species to sugarbeets, Dr. V. F. Savitsky crossed several species of the section Corollinae with sugarbeets. Hybridization resulted in obtaining different hybrids, among them an F_1 hybrid between B. vulgaris (sugarbeet) and B. corolliflora.

The F_1 hybrid developed in a vigorous plant and was fertilized by the gametes of diploid sugarbeets under open pollination in the greenhouse. The first-backcross seeds (b_1) harvested from the F_1 plant by Dr. V. F. Savitsky were given to Dr. Bennett for the test for curly top resistance.

Study of curly top resistance in the vulgaris-corolliflora hybrids was performed by Dr. Bennett; cytological investigations and the further

work with these hybrids, by Helen Savitsky.

The b_1 hybrid seeds were planted by Dr. Bennett in the flat and the seedlings in the cotyledone stage were transplanted to 6-inch pots. After the plants had become established they were inoculated by a virulent strain of the curly top virus (Paso Robles) by means of the beet leafhopper, Circulifer tenellus. The strain of curly top virus used in this test was one of the most virulent strains available for testing and is capable of causing severe symptoms of curly top on varieties of the level of resistance of US 75. Four hundred plants were inoculated.

Some of the inoculated plants began to show vein clearing in 7 days. There was a wide range of reaction to curly top, varying from severe leaf rolling, vein swelling, and stunting to barely visible vein swelling. Thirty-two plants showed no symptoms. These plants were reinoculated at the 10-to 12-leaf stage, using about 30 leafhoppers per plant. Three of the 32 plants showed symptoms and were discarded. The remaining 29 plants that showed no symptoms of curly top were retained. These plants evidently had a very high level of resistance and it seems probable that some of them might even be immune to the strain of virus used.

Limited tests of B. corolliflora have indicated a very high resistance to curly top in this species. Three plants, 2 or 3 months old, were placed in large cages to which approximately 100 leafhoppers carrying the Paso Robles strain of virus were added. To each plant the leafhoppers were allowed to feed for 2 weeks, after which they were removed and the plants treated to destroy nymphs that subsequently hatched. The plants were retained for several months but no symptoms of curly top were observed; and no virus was recovered in the tests with nonviruliferous leafhoppers. These plants were either immune or very highly resistant to the strain of curly top virus used.

Both parents used for hybridization-- sugarbeet and B. corolliflora-- were tetraploid. The cytological study established that the F_1 hybrid was also a tetraploid plant having 36 chromosomes in somatic cells.

Meiosis in F_1 hybrid was very regular and many viable pollen grains and egg cells were formed. Seed setting under open pollination was abundant.

Chromosome number was checked in all b_1 plants in the highly resistant to curly top group, and also in some curly top susceptible plants. All b_1 plants were triploids, or aneuploids approaching to triploids. In the group highly resistant to curly top the majority of plants had 27 chromosomes, 3 plants had 26 chromosomes, 2 plants 28 chromosomes, and 1 plant 24 chromosomes. All b_1 plants carried several B. corolliflora chromosomes which differed from B. vulgaris chromosomes by their length. Obviously the plants in the curly top resistant group carried a chromosome, or chromosomes, of B. corolliflora which were responsible for resistance, or

immunity, to curly top. Although the chromosomes of *B. corolliflora* were also present in the curly top susceptible plants, these chromosomes did not carry the genes which controlled curly top resistance. All first-backcross progeny resembled the wild species *B. corolliflora*, not the sugarbeets, because of the high number of *B. corolliflora* chromosomes they carried.

All b_1 plants were male-sterile and were pollinated by the diploid sugarbeets in the greenhouse. Individual plants differed in the grade of fertility but the majority of plants were sufficiently fertile. The b_2 seeds were harvested for further study.

The results of this study are encouraging. A transmission of the high grade of curly top resistance from F_1 to b_1 hybrid generation should be considered as a beginning of the work, because the b_1 hybrids still carry many chromosomes and many characters of wild species. Obtaining subsequent hybrid generations, selection for curly top resistance, and detailed cytological study of the hybrids, which will throw more light on the processes involved, are necessary for the successful accomplishment of this work.

P A R T VI

SCREENING, SELECTING, AND BREEDING FOR RESISTANCE TO CURLY TOP

A. M. Murphy

C. L. Schneider

Cooperation: Utah State University

The research was supported in part by funds provided through the Beet Sugar Development Foundation (Projects 21 and 27).

CURLY TOP SCREENING TEST, THATCHER, UTAH
By Albert M. Murphy

The curly top disease of sugarbeets continues to be a problem to the sugarbeet industry as judged by breeders' concern to incorporate more curly top resistance into new varieties. One reason for this interest is the expansion of sugarbeet growing into new areas where severe outbreaks of curly top occur. Unfortunately, varieties otherwise best adapted to some of these areas do not carry enough resistance to produce maximum yields in many years and are badly damaged in years of severe curly top outbreaks. Another reason is that new strains of curly top virus capable of damaging present resistant varieties are a constant threat. These reasons seem to dictate a continuing need for a program of breeding for curly top resistance.

The curly top testing program at Logan is carried on in the greenhouse and in the field. This part of the report has to do primarily with testing in the field. The data obtained are recorded in various Parts of this report except for material from the Logan station, some of which is reported in the following tables. Curly top data obtained on material furnish by sugar company breeders were sent to the breeders concerned.

For the past few years, curly top has not been a serious disease in sugarbeets in the Intermountain West, and the incidence of curly top in 1965 in commercial fields was the lowest on record in sugarbeet growing areas of Oregon, Idaho, and most likely Utah. The incidence of curly top in the curly top survey was the lowest since 1939.

For the curly top nursery or screening field, the natural curly top exposure cannot be depended upon as the disease is too sporadic. However, even when the epidemics are artifically created, which has been the procedure in the past several years, the severity of the exposure still greatly depends on weather conditions, because the beet leafhopper (the vector of the curly top virus) is a sun-loving, dry-climate insect that favors arid and semiarid conditions. Certainly weather conditions in 1965 were the most uncooperative imaginable, as it snowed 9 months of the 12 with only June, July, and August escaping, and we had the latest as well as the earliest frosts. The late one on May 6 wiped out many beet plantings; and the early one, September 16, gave one of the shortest growing seasons on record. The September freeze was the coldest since 1891. Heavy rains in June continued to slow the movement of the beet leafhopper and the development of curly top. But in spite of unfavorable weather conditions and the low numbers of beet leafhoppers entering the field, a curly top epidemic resulted which was only slightly less than in 1964. It was satisfactory for all purposes except to make further curly top progress in selecting out of lines already extremely high in curly top resistance.

The degree of disease exposure in the curly top nursery is rated as: light, moderate, heavy, and drastic. A drastic exposure is where practically all the plants in U.S. 33 checks are killed by curly top or would rate a curly top grade of approximately 8. In 1965, the average curly top grade of the U.S. 33 checks was only 4.5; thus the exposure was classed as being light.

In Tables 1, 2, and 3 are recorded the curly top data obtained in field plus greenhouse grades obtained from Dr. C. L. Schneider, on single cross hybrids, hybrids, and inbreds.

This material appeared in yield tests 1, 2, and 3 at Logan, Utah, pages 152, 159, and 161. In addition, cooperative curly top resistance tests are reported on page 16, Part II, and page 173, Part VIII.

TABLE 1. SINGLE CROSS HYBRIDS

Current Number	Description	No. Beets	% C.T. 7-30	% C.T. 8-25	% C.T. 9-14	C.T. Grade[d/] 10-3	C.T. Grade[d/] Green-house
4101	SLC 129 X C672	41	0	29.3	41.5	3	5.9
41112	SLC 129 X SLC 128	61	3.3	21.3	39.3	3.5	4.7
41162	SLC 129 X CT 5A	51	0	17.6	33.3	3	5.7
41201	SLC 129 X SLC 35	56	5.4	8.9	16.1	2.5	6.2
41399	SLC 129 X EL 32	49	2.0	49.0	73.5	4	7.1
41426	SLC 129 X 00.5	56	1.8	51.8	64.3	3.5	6.3
4156	SLC 129 X EL 31	58	5.2	53.4	69.0	4.5	6.8
41147	SLC 129 X CT9	40	0	17.5	27.5	2.5	5.4
41240	SLC 129 X Ov. 3	48	2.1	52.1	58.3	3	5.7
41357	SLC 129 X CT 5B	42	0	47.6	54.8	3	5.2
41388	SLC 129 X Ov. 1	44	15.9	38.6	56.8	3.5	5.8
4103	AI 1 X C672	57	1.8	21.1	35.1	2.5	4.8
41114	AI 1 X SLC 128	56	1.8	17.9	28.6	3	4.2
41163	AI 1 X CT 5A	47	6.4	23.4	34.0	2.5	5.0
41203	AI 1 X SLC 35	46	4.3	41.3	45.7	3	5.1
41401	AI 1 X EL 32	54	0	53.7	72.2	4.5	6.9
41428	AI 1 X 00.5	58	3.4	34.5	50.0	3	5.4
41242	AI 1 X Ov. 3	55	1.8	38.2	45.5	3	5.6
41302	AI 1 X CT9	53	C	17.0	20.8	2.5	5.1
4106	308H01 X C672	53	3.8	35.8	67.9	3.5	6.1
41121	308H01 X SLC 128	56	1.8	46.4	55.4	3.5	5.9
41169	308H01 X CT 5B	50	4.0	46.0	62.0	4.5	5.8
41211	308H01 X SLC 35	55	3.6	41.8	61.8	3.5	6.7
41433	308H01 X 00.5	65	3.1	50.8	72.3	4	6.8
41402	308H01 X EL 32	50	4.0	52.0	68.0	4.5	6.8
4167	308H01 X EL 31	58	5.2	63.8	77.6	5	7.9
41278	308H01 X CT 9A	50	2.0	54.0	66.0	4	6.2
41387	308H01 X Ov. 1	57	3.5	56.1	68.4	4	6.2
41451	308H01 X 3611 (ud)	57	5.3	70.2	84.2	4.5	8.0
41118	NB 1 X SLC 128	36	0	36.1	41.7	3	4.2[f/]
41245[c/]	NB 1 X Ov. 3	48	2.1	50.0	64.6	3	5.1
41306	NB 1 X CT9	39	0	23.1	28.2	2	4.4
41431	NB 1 X 00.5	46	0	34.8	45.6	3	5.1
4163	1104 X EL 31	51	2.0	58.8	88.2	4.5	7.3
1114	9132 X CT5	55	7.3	21.8	38.2	2.5	4.9
4110	0177 X C672	52	5.8	30.8	36.5	3.5	5.1

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TABLE 1. (cont.)

Current Number	Description	No. Beets	% C.T. 7-30	% C.T. 8-25	% C.T. 9-14	C.T. Grade d/ 10-3	C.T. Grade d/ Green-house
4166	0177 X EL 31	47	8.5	59.6	80.8	5	6.3
4111	0178 X C672	59	1.7	32.2	37.3	3	4.6
4159	0178 X EL 31	56	1.8	53.6	76.8	4.5	6.4
41438	0178 X 00.5	54	5.6	44.4	51.8	3.5	5.5
4112	0130 X C672	53	7.5	45.3	43.4	3	4.9
4160	0130 X EL 31	56	8.9	67.8	78.6	5	5.8
41123	0130 X SLC 128	53	3.8	26.4	43.4	3	4.3
41259	0130 X 327-4	49	2.0	40.8	49.0	3.5	4.6
41441	0130 X Ov. 5	56	5.4	33.9	57.1	3	5.8
41122	S3317 X SLC 128	56	1.8	8.9	37.5	3.5	5.0
41156	S3317 X CT9	45	4.4	8.9	24.4	2	3.7 f/
41170	S3317 X CT 5B	53	7.5	18.9	45.3	2.5	4.1
41250 c/	S3317 X Ov. 3	55	9.1	38.2	60.0	3.5	4.1
41406	S3317 X EL 32	56	1.8	42.8	58.9	4.5	5.3
41434	S3317 X 00.5	59	3.4	49.2	76.3	4	4.7
4157	SLC 128 X EL 31	51	7.8	52.9	82.4	5	5.6
41385	SLC 128 X Ov. 1	52	1.9	30.8	61.5	3	4.0
41427	SLC 128 X 00.5	66	1.5	59.1	68.2	4	4.6
4161	CT9 X EL 31	59	5.1	57.6	66.1	4.5	5.5
41117	CT9 X SLC 128	45	4.4	26.7	48.9	3	4.2 e/
41246	CT9 X Ov. 3	54	9.3	40.7	57.4	3	4.6
41430	CT9 X 00.5	58	6.9	41.4	53.4	3.5	4.7
41448 c/	CT9 X 3611 (ud)	44	6.8	56.8	77.3	4.5	6.3 e/
41435	SLC 35 X 00.5	53	3.8	54.7	84.9	4.5	5.1
41105	SLC 35 X 0534	50	4.0	38.0	58.0	3.5	4.0
41161	SLC 35 X CT 5B	58	0	22.4	41.4	3	5.4
41157	SLC 35 X CT9	41	4.9	65.8	85.4	4	5.0
41394	SLC 35 X Ov. 1	54	9.2	57.4	81.5	4	4.8
Check	U.S. 33 a/	1185	8.3	59.6	76.0	4.5	5.5
Check	U.S. 41 b/	401	5.0	35.7	52.1	3	4.9

a/ Average of all U.S. 33 checks in test area.
b/ Average of all U.S. 41 checks in test area.
c/ Placed highest in gross sugar in Logan variety Test No. 1.
d/ Curly top grades from 0 (no symptoms) to 9 (dead).
e/ Results are means of two experiments.
f/ Plants were selected for curly top resistance.

TABLE 5. INBREDS

Current Number	Description	No. Beets	% C.T. 7-30	% C.T. 8-25	% C.T. 9-14	C.T. Grade d/ 10-3	C.T. Grade d/ Green-house
4127	SLC 129 CMS	30	3.3	53.3	60.0	4.5	4.8
41110	SLC 128 CMS	20	0	45.0	55.0	4	5.5
41150	CT9 CMS	43	11.6	25.6	25.6	2.5	5.0
41212	SLC 35 CMS	48	4.2	56.2	64.6	3.5	5.7
4600	C672	42	4.8	14.3	33.3	3	5.2
4602	SLC 129	40	10.0	32.5	42.5	4.5	5.2
4603	EL 31	38	2.6	76.3	100.0	7.5	8.6
4604	FC 503	27	11.1	92.6	100.0	8	6.9
4605	SLC 126	41	4.9	41.5	58.5	4	7.1
4606	SLC 128	40	0	17.5	27.5	2.5	5.1
4607	Line 289	45	6.7	46.7	64.4	4	5.4
4608	SLC 132	50	0	10.0	38.0	3	4.0
4609	CT9	37	13.5	29.7	29.7	2.5	4.4
4610	CT 5B Subline	42	2.4	31.0	54.8	3.5	4.5
4611	00.2	48	4.2	83.3	89.6	5	5.7
4612	EL 33	43	2.3	74.4	90.7	6	7.8
4613	SLC 35	51	7.8	35.3	54.9	4	4.7
4615	Ov. 3	41	7.3	80.5	85.4	4	6.6
4616	SLC 127	26	0	30.8	42.3	3.5	6.2
4617	CT 9A	41	2.4	48.8	73.2	4	5.5
4619	SLC 122	35	0	17.1	31.4	3.5	5.8
4620	CT9	45	2.2	53.3	68.9	4	5.8
4621	(m'm')	39	15.4	92.3	97.4	5.5	8.5
4622	(CT5 X CT9)	33	3.0	63.6	69.7	3.5	5.4
4623	(C515)	10	0	50.0	70.0	5	7.4
4624 c/	CT 5B Subline	53	0	20.8	30.2	3	5.9
4625	36139 (NB-1)	36	5.6	27.8	27.8	1.5	2.3
4626	Ov. 1	43	7.0	48.8	62.8	4	5.5
4627	EL 32	43	2.3	58.1	90.7	6	7.6
4628	SLC 122	44	4.5	15.9	22.7	3	4.8
4629 c/	00.5	56	5.4	46.4	75.0	4	5.6
4630 c/	3611 (ud)	46	8.7	76.1	91.3	5.5	7.5
R4601	R3507-15	39	12.8	89.7	100.0	6.5	6.8
3551-2	CT5	3	0	33.3	100.0	3.5	
3514-1	SLC 130	15	6.7	13.3	33.3	2.5	

TABLE 2. HYBRIDS

Current Number	Description	No. Beets	% C.T. 7-30	% C.T. 8-25	% C.T. 9-14	C.T. Grade d/ 10-3	C.T. Grade d/ Greenhouse
311004-1	SLC 35 X 630 S_2	49	2.0	34.7	46.9	3.5	4.8
31939-9	(7121XCT5) X 630S_2	48	6.2	18.8	22.9	2	5.1
31939-8	(7121XCT5) X 630S_2	51	0	15.7	17.6	2	3.7
31998-1	NB-1 X 630S_2	37	0	16.2	29.7	3	3.5
31955-9	(AI 1X10)129) X 630S_2	52	7.7	40.4	48.1	3.5	4.8
311004-9 c/	SLC 35 X 630S_2	48	0	33.3	60.4	3.5	5.4
31968-9	(129XNemaA) X 630S_2	43	4.7	27.9	44.2	3.5	5.4
31976-1	(Ov.Xm') X 630S_2	48	2.1	14.6	27.1	3	4.7
31940-1 c/	(7121XCT5) X 630S_2	55	0	14.5	16.4	3	4.8
31980 c/	(9132XCT5) X 3611 (ud)	40	5.0	40.0	52.5	3.5	5.6
31943	(133XCT5) X 3611 (ud)	46	4.3	43.5	56.5	3.5	5.3
31960-9	(AI-1X130) X 630S_2	59	1.7	27.1	32.2	2.5	4.8
1101	(129XCT5) X (630XCT5)	49	0	8.2	30.6	2	4.2
1114	9132 X CT5	44	0	11.4	18.2	2	3.9
31976-7	(Ov.Xm'm') X 630S_2	41	2.4	26.8	41.5	2.5	4.6
31945-1	(130X289) X 630S_2	48	2.1	25.0	43.8	3	4.4
Check	U.S. 33 a/	1185	8.3	59.6	76.0	4.5	5.5
Check	U.S. 41 b/	401	5.0	35.7	52.1	3	4.9

a/ Average of all U.S. 33 checks in test area.
b/ Average of all U.S. 41 checks in test area.
c/ Placed highest in gross sugar in Logan variety Test No. 2.
d/ Curly top grades from 0 (no symptoms) to 9 (dead).

TABLE 3. (cont.)

Current Number	Description	No. Beets	% C.T. 7-30	% C.T. 8-25	% C.T. 9-14	C.T. Grade d/ 10-3	C.T. Grade d/ Greenhouse
3564-6	CT9	19	5.3	84.2	84.2	5.5	
3520-2	CTR sel.	28	3.6	35.7	60.7	4	
3546-3	0548 Subline	43	0	7.0	20.9	2	4.5
3522-8	0548 Subline	40	15.0	37.5	57.5	3	
S3317-5		42	0	9.5	40.5	3	
2914	AI 1	45	2.2	20.0	51.1	3	4.1
2923	NB 1	27	0	18.5	22.2	2	
Check	U.S. 33a/	1185	8.3	59.6	76.0	4.5	5.5
Check	U.S. 41b/	401	5.0	35.7	52.1	3	4.9

a/ Average of all U.S. 33 checks in test area.
b/ Average of all U.S. 41 checks in test area.
c/ Placed highest in gross sugar, in Logan variety Test No. 3.
d/ Curly top grades from 0 (no symptoms) to 9 (dead).

GREENHOUSE TESTS OF CURLY TOP RESISTANCE

C. L. Schneider

Material and Methods

Two groups of sugarbeet strains were tested for curly top resistance in the greenhouse at the A.R.S. Crops Research Laboratory, Logan, Utah, in 1965. Group I comprised 243 entries which had also been tested in field exposures of curly top in plots at Thatcher, Utah, by Albert M. Murphy in 1964. The greenhouse tests of the entries in Group I were begun in April 1964 and were completed in March 1965. Most of the Group I entries were supplied by J. Clair Theurer of the Logan Station.

Group II comprised 192 entries, many of which were also included in curly top evaluation field plots at Thatcher in 1965. J. Clair Theurer supplied 83% of the entries in Group II; John O. Gaskill of the Fort Collins station supplied 15%, and the remainder came from miscellaneous sources. Group II entries were tested during the period of March-December, 1965.

Viruliferous beet leafhoppers (Circulifer tenellus) were obtained for inoculation tests as follows: Insects from non-viruliferous stocks were caged for at least 7 days on sugarbeets infected with a virulent culture of curly top. Cages were of plastic and organdy (fig. 1) and of the type developed originally at USDA Entomology Laboratory, Twin Falls, Idaho. The virus culture, designated as AIA, was isolated in 1962 from a sugarbeet plant exposed in the greenhouse to leafhoppers collected in the desert near Promontory, Utah, and had been maintained subsequently in plants of sugarbeet varieties rated resistant or moderately resistant to curly top.

Techniques for inoculating seedlings were adapted from methods described by Giddings (1). Plants to be inoculated were transplanted as seedlings, 4 per 6" pot. When the first true leaves began to appear, the seedlings were exposed to viruliferous leafhoppers. There were some differences in the methods used to inoculate plants of Group I entries and those of Group II. In Group I, one small glass cage (2) containing one leafhopper was attached to a cotyledon of each plant. After plants had been exposed to the insects for approximately 7 days in the greenhouse, each cage was removed by cutting the cotyledon near the site of attachment to a cage. In Group II, 2 cages-- each containing 1 leafhopper-- were attached to each plant, one on each cotyledon. During the exposure period of about 7 days, the plants were kept in a growth chamber maintained at about 27° C and with a 24-hr. photoperiod (fig. 2). Upon removal of vector cages, plants were transferred to a greenhouse.

About 6 weeks after inoculation, incidence of infection (no. of plants with curly top symptoms/total no. of plants inoculated) and severity of curly top of each entry were determined. Each plant inoculated was assigned a numerical severity rating ranging from 0 (no symptoms) to 9 (plant dead). It was not possible to determine readily whether symptomless plants had escaped adequate exposure to the virus or whether they were truly immune to curly top; therefore, they were not included in the computation of the mean curly top severity score. The mean pre-symptom period (time in days, from inoculation until initial expression of curly top symptoms) of each entry was also determined.

Limitations of space and time precluded testing all entries simultaneously. Usually each test comprised 9 entries plus moderately resistant check variety, U.S. 41, included as a basis for comparison. Each entry was represented by 20 plants in 5 pots and the experiment was arranged on the bench in a randomized block. Entries with poor stands or those that gave erratic results were tested a second time.

Results

Performance of the check variety, U.S. 41, in each test of Group II is shown in Table 1. Similar behavior of U.S. 41 was noted in tests of Group I, conducted earlier and reported previously in part (3). There were considerable differences in curly top incidence, severity rating and pre-symptom period of U.S. 41 in different tests, albeit the same curly top culture was employed in each test. Some variables that are considered as causes of these differences include: variation in virus content of curly top source plants on which leafhoppers were fed prior to inoculation of seedlings; variation between lots of leafhoppers in ability to transmit curly top; and variation in environmental conditions in the greenhouse, especially temperature and light. Because of the apparent variation in intensity of disease exposure or development between tests, as evidenced by check variety U.S. 41, curly top reaction of each entry is expressed in percent of that attained by U.S. 41 in the same test.

Reactions of the entries in Group I have already been reported in part (3). Field and greenhouse curly top reactions of the lines included in 1964 tests and 139 of the lines included in 1965 tests are shown in figs. 3 and 4. Field data were obtained and furnished by A. M. Murphy. Highly significant correlation coefficients of .471 (Group I lines) and .667 (Group II lines) indicate positive association among field and greenhouse curly top evaluations.

With curly top incidence and severity ratings of Group II entries, there was a relatively low degree of correlation (Fig. 5). With pre-symptom period and curly top severity, on the other hand, there was significant negative correlation (fig. 6).

Fig. 1.--Cage containing leafhoppers on curly top infected sugarbeet.

Fig. 2.--Inoculation cages on sugarbeet seedlings in growth chamber.

Detailed reports on performance of entries in these tests have been forwarded to the cooperators.

Literature Cited

1. Giddings, N. J. 1937 A greenhouse method for testing resistance to curly top in sugar beets, Phytopathology 27:773-779.

2. ______________ 1939 A small cage for insect vectors used in plant inoculations, Phyopathology 29:649-650.

3. Schneider, C. L. 1965 Greenhouse tests of curly top resistance. Sugarbeet Research - 1964 Report. Sugarbeet Investigations, A.R.S., U. S. Department of Agriculture, pp. 98-105.

Table 1 - Reaction of check variety U.S. 41 in a series of greenhouse tests (Group II) of curly top resistance of sugarbeet strains in 1965

Test No.	Curly Top[a] Incidence (pct.)	Curly Top Severity Grade[b]		Pre-Symptom Period[c] (days)	
		Range among individuals	Mean	Range among individuals	Mean
1	95	5-9	6.1	3-12	6.5
2	100	4-9	5.3	8-40	12.0
3	90	4-8	5.6	5-19	10.1
4	75	4-7	5.5	10-30	15.3
5	90	2-6	4.5	9-16	12.8
6	55	3-6	4.6	9-14	11.4
7	63	3-6	4.4	5-34	12.9
8	85	2-9	5.3	7-40	13.0
9	75	2-6	4.2	8-40	14.8
10	80	3-6	4.8	10-19	14.4
11	70	3-9	4.7	11-19	14.5
12	100	2-8	5.4	9-20	12.6
13	90	4-7	4.2	8-12	10.9
14	90	3-6	4.5	7-27	13.6
15	79	2-7	4.5	7-28	14.8
16	95	4-7	4.4	6-13	9.7
17	85	3-8	5.2	7-29	14.5
18	100	3-6	4.6	10-40	15.6
19	60	4-6	4.9	12-16	12.7
20	50	3-7	5.1	11-21	13.8
21	80	4-8	5.5	9-14	13.1
AVERAGE:	81.3		4.9		12.8

a No. of plants with curly top symptoms divided by total no. of plants inoculated.

b Numerical ratings from 1 (very light infection) to 9 (plant dead).

c Number of days from exposure to curly top until initial appearance of curly top symptoms.

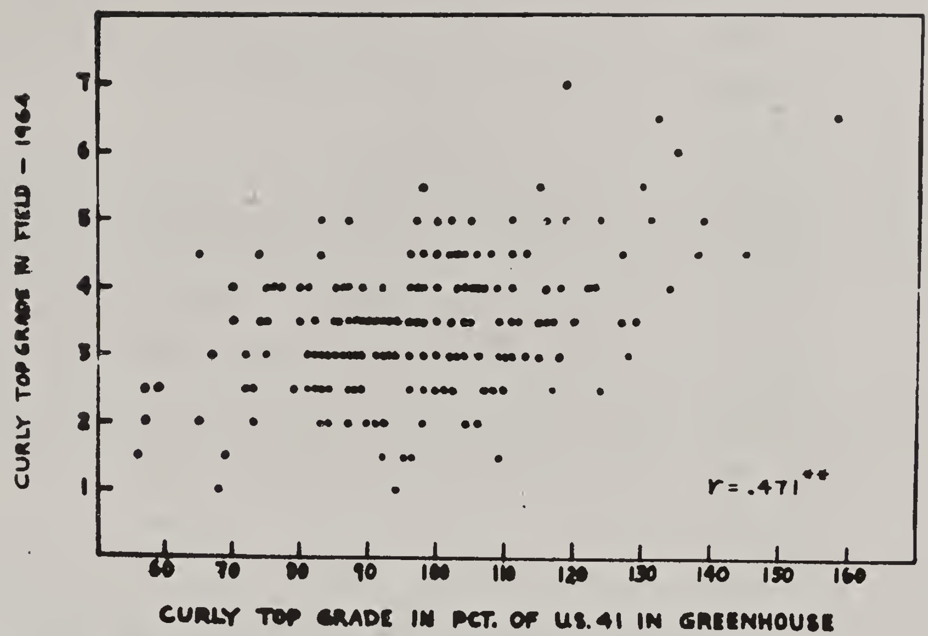

Fig. 3 - Distribution of Group I sugarbeet lines according to curly top grade in greenhouse and field tests.

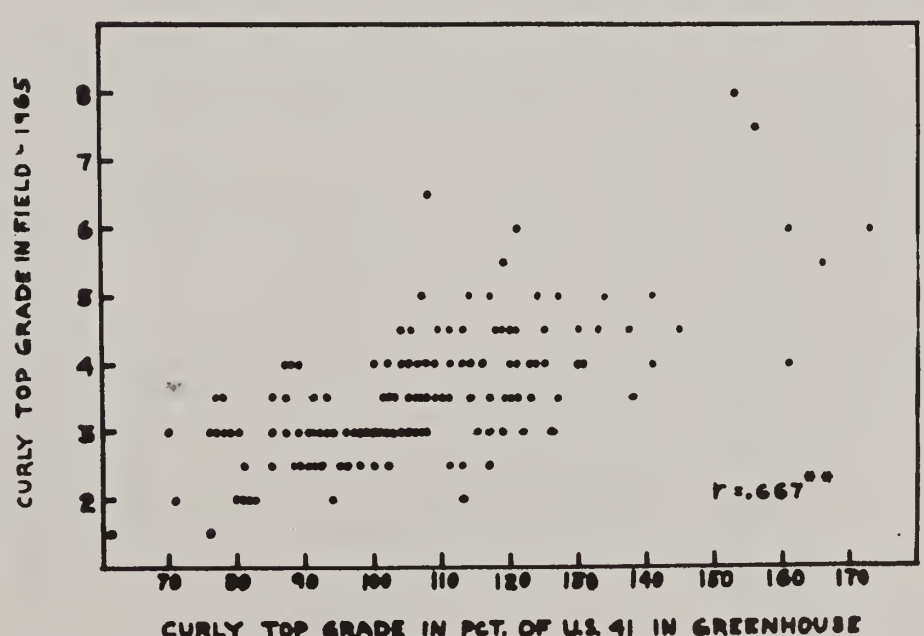

Fig. 4 - Distribution of Group II sugarbeet lines according to curly top grade in greenhouse and field tests.

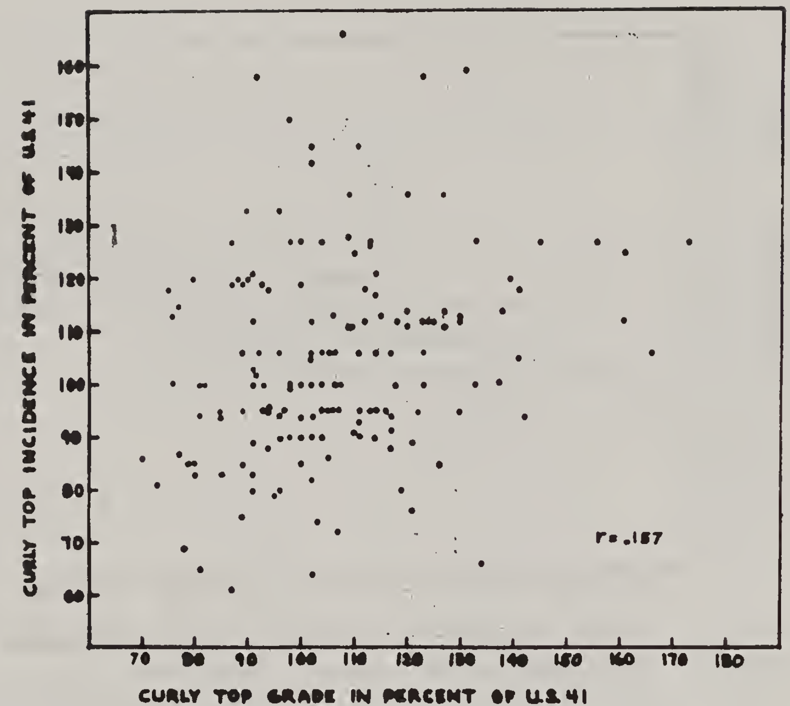

Fig. 5 - Distribution of Group II sugarbeet lines according to curly top grade and incidence in the greenhouse.

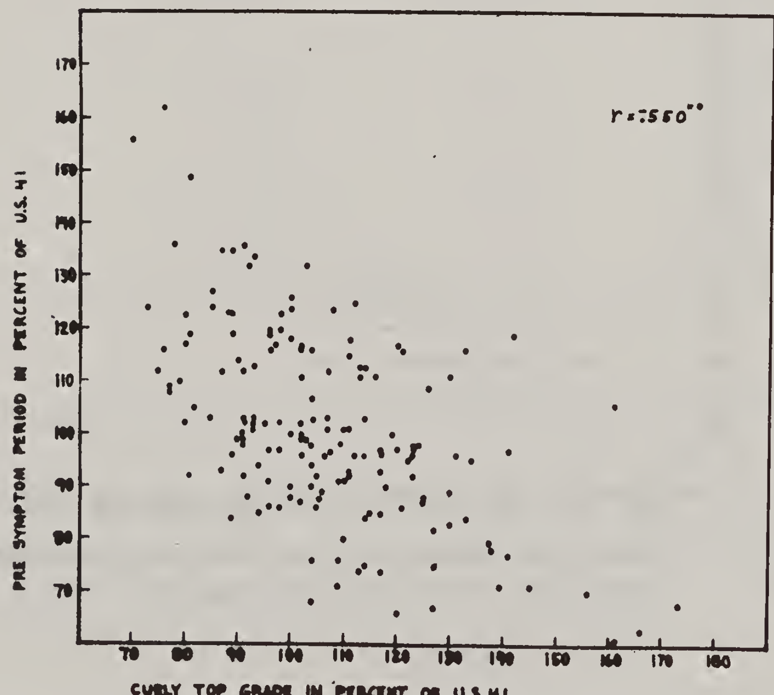

Fig. 6 - Distribution of Group II sugarbeet lines according to curly top grade and pre-symptom period in the greenhouse.

DETERMINATION OF SOME FACTORS INFLUENCING INCIDENCE OF CURLY TOP OF SUGARBEET SEEDLINGS

C. L. Schneider and Ali M. Jafri

In greenhouse testing of sugarbeets for curly top resistance, it is highly desirable that all susceptible plants show curly top symptoms after inoculation. Symptomless plants complicate greatly the evaluation of resistance, because of the uncertainty whether they indicate disease immunity or disease escape.

In our greenhouse tests, curly top incidence has varied considerably from one test to another, even in the same variety and with the same virus culture. For example, 100% of the seedlings of variety U.S. 41 became infected in one test, and only 50% became infected in a succeeding test 9 days later.

Several factors that influence curly top incidence in sugarbeets have been reported. Bennett, with artificially fed leafhoppers, showed: males are superior to females in transmitting curly top and adults are superior to nymphs; 2 leafhoppers per seedling on separate cotyledons are superior to 2 on one cotyledon or one per plant; and incidence increases with time of feeding on test seedlings up to 3rd or 4th day (1). Bennett and Wallace reported that individual leafhoppers vary in ability to transmit curly top (2). Carsner and Stahl showed that plants kept in the dark during inoculation period are more readily infected through cotyledons than through true leaves (3). Giddings, by comparing incidence of curly top in test seedlings showed that virus concentration is higher in curly top susceptible sugarbeets than in resistant ones and that virus concentration is higher in plants 3-12 weeks after they have been infected than it is 3-8 months afterwards (5). He also showed that curly top resistance of sugarbeet seedlings increased during an 8-day period (6). Vest showed that inoculation of tomato seedlings through cotyledons resulted in higher curly top incidence than inoculation through the first true leaves (8).

With the aim of improving efficiency of inoculation techniques and methodology employed in greenhouse curly top resistance tests by reducing the likelihood of disease escape, we studied the effects of some biological and environmental factors on incidence of the disease in sugarbeet seedlings. Included were factors studied by previous investigators (1, 2, 3, 5, 6) in order that their pertinence to the particular circumstances in which our greenhouse tests are conducted could be determined.

METHODS

The techniques, described as follows, were used except where others are specified. Beet leafhopper (Circulifer tenellus) adults from nonviruliferous stock colonies were caged for about 7 days on inner leaves of

sugarbeets, infected with a virulent strain of curly top virus (AIA). Seedlings, 4 per 6" pot, were exposed to leafhoppers from infected plants when the first true leaves began to appear. A small glass cage (4), containing one leafhopper, was attached to each cotyledon for a period of 5-7 days. During the inoculation period, plants were kept in a growth chamber maintained at 27° C and provided with constant fluorescent and incandescent illumination of about 1300 foot-candles. Relative humidity, not regulated in the chamber, usually equaled 30-40% with occasional highs near 90% and lows near 20%.

Plants were examined daily for appearance of curly top symptoms. About 6 weeks after inoculation, final counts of diseased plants were made, and severity of curly top was determined in accordance with a previously described method (7).

RESULTS AND CONCLUSIONS

1. Comparison of Growth Chamber with Greenhouse - Experiments conducted in October and November showed seedlings of 2 curly top resistant sugarbeet varieties, inoculated while in the growth chamber, to have higher incidence of curly top than seedlings inoculated while in the greenhouse (Table 1). A highly susceptible variety included in the first experiment showed about the same incidence in both environments. Little difference in curly top severity was noted between plants inoculated in the growth chamber and those in the greenhouse. Inasmuch as environmental conditions change considerably in our greenhouse throughout the year, it is highly probable that a more accurate assessment of the advantages of the growth chamber for conducting inoculation tests could be made after a series of similar tests throughout a year.

2. Age of Seedlings - In a resistant variety, curly top incidence decreased markedly as seedling age increased (Table 2). With a very susceptible variety there was little difference. Both varieties showed more severe curly top symptoms when inoculated 17 days after planting than when inoculated 25 or 35 days after. These results confirm previous reports of increased resistance of young sugarbeets with increase in age (6).

3. Site of Inoculation - With the exception of highly susceptible variety SL 742, curly top incidence was higher when inoculation cages were attached to cotyledons than when they were attached to first true leaves. (Table 2 and 3). Site of infection did not affect curly top severity, however.

4. Inoculation Period - In experiments to compare efficacy of 1, 3, 5 or 7 day inoculation periods, highest curly top incidence was attained after a minimum of 3-5 days, according to variety inoculated. (Table 4). Curly top severity did not appear to be affected.

TABLE 1. Effect of greenhouse and growth chamber environments during inoculation period on incidence and severity of curly top in sugarbeet seedlings

Treatment	Experiment #1 (20-25 Oct, 1965)[a]				Experiment #2 (17-23 Nov, 1965)[a][b]	
	Var. SL 742		Var. SL 0667		Var. US 41	
	C.T. Pct	C.T. Grade[c]	C.T. Pct	C.T. Grade[c]	C.T. Pct	C.T. Grade[c]
Greenhouse	89.5	8.0	70.6	4.1	40.0	4.4
Growth Chamber	87.5	8.5	80.0	4.3	70.0	4.7

(a) Results based on 20 plants included in each treatment.
(b) One plant in the control series had curly top.
(c) CT grades range from 0 (no disease) to 9 (plant dead).

TABLE 2. Effect of age of plant and site of inoculation on incidence and severity of curly top in sugarbeet seedlings

Treatment		Var. SL 742[a]		Var. SL 0667[a]	
No. days from planting to inoculation	Site of Inoculation	C.T. Pct	C.T. Grade	C.T. Pct	C.T. Grade
17	Cotyledon	75.0	7.4	60.0	4.0
25	Cotyledon	65.0	5.9	45.0	2.4
25	1st true leaf	75.0	6.2	35.0	2.6
32	Cotyledon	70.0	5.9	15.0	2.7
32	1st true leaf	80.0	5.5	0	0

(a) Results based on 20 plants included in each treatment.

TABLE 3. Effect of site of inoculation on incidence and severity of curly top in sugarbeet seedlings

Site of Inoculation[a]	Variety U. S. 33[b]		Variety U. S. 41[b]	
	C.T. Pct	C.T. Grade	C.T. Pct	C.T. Grade
Cotyledon	90.0	5.2	90.0	4.4
First true leaf	50.0	5.3	65.0	4.8

(a) Plant inoculated 26 days after planting.
(b) Results based on 20 plants inoculated.

TABLE 4. Effect of time of exposure to viruliferous beet leafhoppers on incidence and severity of curly top in sugarbeet seedlings

Exposure Period (days)	Variety SL 742 (a)		Variety SL 0667 (a)	
	C.T. Pct	C.T. Grade	C.T. Pct	C.T. Grade
1	77.5	7.5	60.0	4.7
3	82.5	8.1	77.5	4.3
5	90.0	8.3	71.0	4.3
7	90.0	7.8	77.5	4.9

(a) Results based on means of 2 experiments; in each experiment, 20 plants of each treatment were inoculated.

TABLE 5. Effect of sex of beet leafhopper vectors on incidence and severity of curly top in sugarbeet seedlings

Sex of Leafhoppers	Experiment #1 (a) (Variety SL 742)		Experiment #2 (b) (Variety U.S. 33)	
	C.T. Pct	C.T. Grade	C.T. Pct	C.T. Grade
Male	87.2	8.5	75.0	6.0
Female	92.3	8.1	82.5	5.8

(a) Results based on 39 plants inoculated.
(b) Results based on 40 plants inoculated.

TABLE 6. Effect of stage of development of beet leafhopper vectors on incidence and severity of curly top in seedlings of sugarbeet variety U.S. 33

Stage of Leafhopper	Percent Curly Top (c)	Curly Top Severity
Nymph (a)	89.7	5.9
Adult (b)	89.4	6.0

(a) Results based on 39 plants inoculated.
(b) Results based on 38 plants inoculated.
(c) Two plants in control series had curly top.

5. Sex and Stage of Development of Leafhopper - In each of 2 experiments, curly top incidence was slightly higher (+5.1% and +7.5%) among plants inoculated with female leafhoppers than among those inoculated with males (Table 5). Adults and nymphs were about equal in ability to transmit curly top (Table 6). Curly top severity was not affected in either instance. Our studies did not reveal differences in ability to transmit curly top due to sex and age of leafhopper, as reported by Bennett (1), possibly because of gross differences in methods of virus acquisition by the vectors that were employed in each study.

6. Number of Leafhoppers Per Seedling - When 2 leafhoppers were placed on each seedling - one per cotyledon - curly top incidence was subsequently slightly higher than when one leafhopper was placed (Table 7). Placement of 2 viruliferous leafhoppers per plant in one cage on resistant variety SL 0667 resulted in less curly top incidence than did placement of 2 leafhoppers per plant, each in a separate cage on a separate cotyledon. These results tend to confirm those of a similar study (1).

7. Pre-inoculation Dark Period - Seedlings covered with inverted light-proof fiber pots for 24 hours prior to inoculation did not show higher curly top incidence than untreated seedlings, as these results show:

Treatment	Plants with curly top/total plants inoculated: Variety US 33	Variety US 41
Pre-inoculation dark period	17/18	18/20
Control	16/16	17/19

8. Virus Acquisition Period - It has been reported that a feeding period in excess of 2 days on a virus-infected plant is required for leafhoppers to acquire a maximum charge of virus (2). Results of our exploratory experiment, outlined as follows, show that acquisition periods of 14 and 21 days did not increase curly top incidence above that obtained after a 7-day period that we have customarily used in our inoculation tests:

Virus acquisition period (days)	Percent curly top in sugarbeet varieties[a]: SL 68	US 75	SL 742
7	80.0	80.0	90.0
14	40.0	35.0	75.0
21	80.0	70.0	80.0

[a] Results based on 20 plants of each variety - treatment combination inoculated.

9. Curly Top Source Plants - Leafhoppers were caged concurrently on 2 sugarbeet plants, each infected with the same virus culture and each showing about the same degree of curly top severity. The plants differed

TABLE 7. Effect of number of beet leafhopper vectors per plant on incidence and severity of curly top in sugarbeet seedlings

No. Leafhoppers		Var. SL 742 (a)		Var. SL 0667 (a)	
Per Inoculation Cage	Per Seedling	C.T. Pct	C.T. Grade	C.T. Pct	C.T. Grade
1	1	90.0	7.8	70.0	4.9
1	2 (b)	95.0	8.2	75.0	5.5
2	1	95.0	7.3	55.0	5.8

(a) Results based on 20 plants per treatment.
(b) One cage was placed on each cotyledon.

TABLE 8. Comparison of curly top incidence in 2 groups of sugarbeets each inoculated with virus from a different source plant

Virus Source Plant		Percent curly top in seedlings of each sugarbeet variety exposed to leafhoppers from each virus source plant		
Variety	Length of time infected with curly top	SL 742	US 75	SL 0667
US 41 (a)	10 mos.	13.3	18.3	1.7
3576-1 (b)	7 mos.	77.5	60.0	47.5

(a) Results based on 45 plants of each variety inoculated with virus from this source plant.
(b) Results based on 30 plants of each variety inoculated with virus from this source plant.

in the length of time they had been infected with curly top and were of different varieties. Curly top incidence among seedlings exposed to insects from one of the virus-source plants was considerably higher than among seedlings exposed to insects from the other (Table 8). It is most likely that these differences in curly top incidence are indicative of differences in virus concentration in the source plants and are governed by factors enumerated by Giddings (5).

SUMMARY

Inoculation of sugarbeet seedlings in a controlled environment growth chamber resulted in higher curly top incidence than did inoculation in a greenhouse. As age of the seedlings at time of inoculation increased, curly top incidence decreased. Inoculation through cotyledons gave higher curly top incidence than inoculation through first true leaves. A minimum of 3-5 days inoculation period was necessary for maximum curly top incidence. Curly top incidence increased with increase in number of leafhoppers per seedling. Incidence of curly top differed according to source plant. Sex and stage of development of leafhoppers did not noticeably affect curly top incidence. Pre-inoculation period of darkness or an increase in virus acquisition period above 7 days did not increase curly top incidence.

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P A R T VII

STUDIES ON ASEXUAL TRANSMISSION AND GENETICS OF MALE STERILITY IN SUGARBEET[1/]

- - -

EVALUATION OF INBRED LINES AND HYBRID VARIETIES

- - -

STUDIES ON QUALITY

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STUDIES ON SEMI-MALE-STERILE SUGARBEETS

By J. C. Theurer and E. H. Ottley

The 1945 proposal made by Dr. F. V. Owen (1) for the inheritance of cytoplasmic male sterility (CMS) has been a useful tool for production of commercial hybrid sugarbeets. However, at the time of publication, two decades ago, Owen himself recognized that the two proposed genetic factors (X and Z) conditioning CMS did not give a complete answer for the inheritance of this character. Certain exceptions, mainly associated with semi-male sterility, were pointed out. He suggested that the complexity of segregation in certain semi-male-sterile lines would have to be explained by genetic factors other than X and Z.

Hogaboom (2) studied segregation in semi-male-sterile plants and proposed a genetic factor (Sh) which enhanced the production of pollen of Sxx genotype. By contrast many lines we have observed appear to carry a gene(s) that enhance male sterility.

An attempt was begun at Logan in 1964 to learn more about semi-male sterility by seeking answers to the following questions: How much variation occurs within partial-fertile plants? Can we isolate stable partial-fertile genotypes? What information can be gained by studying segregation of progenies from a single partial-fertile plant?

All plants for these studies were grown in a greenhouse maintained between 70° and 80° F. Supplemental incandescent light was supplied for 8 hours per day. Fertility was determined by microscopic examination of a random sample of pollen stained with aceto-carmine. In cases where anthers failed to dehisce, a pollen sample was obtained by squashing a random sample of anthers in a drop of stain on a microscope slide.

Experiment #1

Three annual CMS hybrids, previously observed to segregate male-sterile and semi-male-sterile progeny, were planted in the greenhouse in January, 1964. Each plant of the three lines was carefully observed for dehiscence of pollen during the last week of March. The degree of fertility was determined microscopically, then the plants were bagged with a #10 white paper bag for seed production. Twelve plants each produced 20 or more selfed seeds. The seed was sown in ground beds in the greenhouse and pollen fertility readings were made in December.

Results

As shown in Table 1, the various lines segregated in a range from male-sterile to apparently fertile offspring. There was no correlation between the fertility of the original parent and that of the progenies.

Lines selected for a low percentage of fertile pollen produced, on the average, as many fertile offspring as did the 90% pollen parents. These results suggest that semi-male sterility inheritance is very complex and that stable semi-male-sterile lines are difficult, if not impossible, to isolate. The variation observed could be attributed to a series of modifier genes, to instable cytoplasm, to environmental effects, or to a combination of these factors.

Experiment #2

In another study several greenhouse plants were repeatedly sampled at weekly intervals to determine the variation among branches of an individual plant. Each week pollen was collected from a different branch of the plant.

Results

A sample of the results observed is given in Table 2. The fertility varied from male-sterile to 90% stainable pollen. There was a tendency for the fertility of a plant to increase until seed on some branches was nearing maturity and then to decrease again. This may have been due to environment or to physiological changes in the plant, as suggested by Stein et. al (3).

Experiment #3

The line SL 7121 was released to the sugarbeet industry in 1960 as SLC 133 CMS. It is a cytoplasmic male-sterile line that was used extensively in combining ability tests in 1959. Dr. F. V. Owen reported (1960 Research Report) that this line may need some roguing to white anther. When white-anther CMS 7121 plants were crossed with good O-type pollinators, the offspring were 100% male-sterile (Table 3). However, when 7121 was crossed to non-O-type inbred CT 9 or to SLC 130 (9136), male-sterile and partial male-sterile progeny occurred. Backcrosses of (7121 X SLC 130) X SLC 130 gave mostly male-sterile offspring. This result is not uncommon with backcrosses of semi-fertile plants.

We selected a single partial-fertile plant of 9136 (SL 7121 X SLC 130) for study of the inheritance of semi-male sterility. This plant was bagged and subsequent seed planted in 4-inch pots in the greenhouse in August 1964. When the plants were 3 months old, they were transferred to a cold chamber (45° F) for a 2-month photothermal induction then returned to the greenhouse. All S_1 (F_2) plants were observed for pollen fertility visually and microscopically. Pollen-producing plants were allowed to self under bags and male-sterile segregates were crossed to the annual SLC 03 or biennial SLC 129 O-type pollinators.

TABLE 1. -- Segregation of semi-male-sterile plants in the greenhouse.

Current number	Parent fertility percent	Percent fertility (upper class units)												Total number plants
		MS	10	20	30	40	50	60	70	80	90	100	Av.	
B 4921-3	1	7	3	1	0	0	0	0	0	1	0	1	17.7	13
B 4921-11	40	13	1	3	1	0	1	1	1	1	1	0	19.6	23
B 4923-2	10	2	4	5	1	2	1	1	3	2	3	0	41.7	24
B 4923-4	50	0	5	1	1	1	1	2	4	3	4	0	54.1	22
B 4923-5	70	1	3	4	0	0	1	4	1	3	7	0	55.8	24
B 4923-3	80	2	3	2	0	1	1	0	2	2	4	3	56.0	20
B 4923-1	90	6	7	0	1	0	3	0	3	2	7	2	46.8	31
B 4924-3	1	7	1	0	3	0	0	0	1	2	5	0	41.0	19
B 4924-9	1	10	4	4	2	0	0	0	1	6	11	0	47.8	36
B 4924-4	90	3	2	1	2	0	0	2	1	1	5	0	48.2	17
B 4924-6	99	14	1	1	2	0	1	2	2	2	4	2	36.1	31

TABLE 2. -- Variation among branches of individual plants

Variety	Plant No.	Pollen readings Initial	1	2	3	4	5
B 4149	3	MS	10	60	60	60	30
B 4152	4	Trace	40	90	50		
B 4152	6	20	90	60			
B 4157	3	MS	30	10			
B 4162	2	Trace	20	Trace	20	10	
B 4162	1	25	Trace	30	70		

TABLE 3. -- Fertility of SL 7121 CMS crossed to O-type and non-O-type pollinators

Hybrid	Generation	Fertility reading MS No.	PF No.	F No.
7121 X SLC 129	F_1	31	0	0
7121 X SLC 128	F_1	35	0	0
7121 X SLC 130	F_1	68	19	0
7121 X CT9	F_1	37	23	0
(7121 X SLC 130) SLC 130	b_1	115	6	0
(7121 X SLC 130) SLC 130	b_1	50	2	0
(7121 X SLC 130) SLC 130	b_1	13	0	0

Results

Each flower on the selected SL 9136 plant was tagged with a small jewelry tag to note the characteristics of the individual flower. One flower that had shrunken, brown, male-sterile anthers produced a viable embryo. All other seed resulted from flowers having three or more yellow partial-fertile to fertile anthers.

S_1 (F_2) progeny of this plant segregated 18 completely male-sterile, 21 partial male-sterile and 3 apparently normal pollen-producing plants. These results fit a 9:7 ratio with a X^2 probability of 0.90. This would suggest that semi-male sterility was governed by two complementary genes. Anthers varied from shrunken, brown, and empty to plump and yellow with considerable inter- and intra-flower variation on each plant.

Seven male-sterile segregates which were crossed to SLC 03 annual O-type pollinator were evaluated for fertility in December 1965 and January 1966, in a single bay of the greenhouse. Under a 3X magnifier, anthers from three of the most fertile-appearing flowers and two of the least fertile-appearing flowers on each plant were selected to determine pollen fertility. Five microscopic fields of 750X (av. of 100-150 pollen grains) were counted for each of the five samples taken from a plant. Considerable inter- and intra-flower variation was observed. Stainable pollen ranged from 0 to 95% with an average of 52%. Segregation for fertility of these hybrids is shown in Table 4.

Since all male steriles were produced on a single plant, they should carry the same sterile cytoplasm. Furthermore, the SLC 03 should be homozygous for genes conditioning sterility since this line was in the S_{10} generation of inbreeding.

If Sxxzz represents the genotype of CMS and Nxxzz, the genotype for O-type, we would expect only male-sterile offspring. Only line 5935 would fit this conclusion. All 37 plants of this line were originally scored as male sterile, however, a few pollen-bearing flowers developed 2 weeks later on a side branch of one plant. A hypothesis that would fit all of the data is hard to visualize.

The data show that all white-anther male steriles are not of the same genotype, that the SL 03 annual is not an O-type pollinator with these male steriles, and that semi-male sterility inheritance is very complex.

Biennial crosses of male-sterile X SLC 129 and selfed progenies of the partial-fertile to fertile F_2 segregates have been photothermally induced and are presently growing in the greenhouse. Data on fertility of these lines will not be available until a later date.

TABLE 4. -- Pollen fertility of male-sterile segregates of 9136⊗ crossed to 03 annual O-type pollinator

Line No.	Pollen fertility MS	PF	F	Total plants
	No.	No.	No.	No.
5913	32	4	0	36
5921	0	5	0	5
5924	16	8	3	27
5931	17	53	14	84
5933	36	1	0	37
5936	0	5	6	11
5937	3	2	1	6

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Asexual Transmission of Cytoplasmic Male Sterility

by J. C. Theurer and E. H. Ottley

Studies on possible graft transmission of cytoplasmic male sterility were continued in 1965. More data were sought concerning apparent CMS segregates in grafted lines from CT5 parentage. (See Table 7, 1964 Research Report.) In addition, the G_1 generation of grafts made in 1963-64 was evaluated to see if there was evidence of graft transmission of the plasmic factor governing male sterility in those lines. Methods of study have been given in previous reports.

Results

CT5 Biennial Graft Backcrosses. In 1964 four out of nine G_1 male-sterile plants from CT5 grafts gave male-sterile progeny when they were backcrossed to SLC 03 (annual O-type pollinator homozygous AA). These four lines were GB 4101, GB 4108, GB 41015, and GB 41048. In 1965 another population of GB 4101 was studied and again resulted in the same frequency of 17 male-sterile to 1 partial-fertile plant (Table 1). Evidence for additional self and backcross generations involving these families again verify that the male sterility is of the cytoplasmic type. Backcrosses result in mostly male-sterile progeny rather than all fertile as expected for the Mendelian type. Selfed populations give poor fits to the 3:1 ratio expected with genetic male sterility. CT5 is a non-O-type pollinator; therefore, some partial-fertile segregates would be expected when it was crossed to a cytoplasmic male-sterile line.

It is possible that the original line was carrying male-sterile cytoplasm and segregating for the genes conditioning CMS. We cannot say we have been successful in transmitting the plasmic factor across the graft union until we can prove the latter point incorrect.

1963-64 Grafts in the G_1 Generation. The fertility of five lines in the G_1 and one biennial line in the G_0 are given in Table 2. Two of the lines had male-sterile progeny. Number 94414 segregated as high as one-third male-sterile plants. Our records indicate that these two lines do not carry the male-sterility gene. However, we cannot ignore this possibility.

Further study will have to be made to be assured that these male-sterile plants are of the cytoplasmic type.

Table 1.--Self and backcross generations of four CT5 grafted families giving evidence of cytoplasmic male sterility.

Family	Line number	Description	Fertility MS	PF	F
			No.	No.	No.
GB 4101	- - -	(CT5/1114 CMS graft) MS X SLC 03	33	2	0
	GB 5642-2	GB 4101-12 selfed	5	12	10
	GB 5201-1	GB 4101 MS X SLC 03	10	3	0
	GB 5248	GB 5201 MS X SLC 03	25	0	0
GB 4108	GB 5245	GB 4108 MS X SLC 03	60	10	2
GB 41015	GB 5202	GB 41015 MS X SLC 03	47	5	4
	GB 5249	GB 5202 MS X SLC 03	29	8	0
GB 41048	GB 5203	GB 41048 MS X SLC 03	46	2	0
	GB 5635	GB 41048 selfed	4	2	0

Table 2.--Fertility of the G_1 generation of grafts made to SLC 03 CMS in 1963-1964.

Current number	Description	Fertility distribution MS	PF	F
		No.	No.	No.
GB 46210	M3579-5 scion selfed	0	3	35
GB 4663	94414 scion selfed	154	164	91
GB 46130	94602.1 scion selfed	9	205	409
GB 4680	94625 scion selfed	0	18	289
GB 4601	SLC 03 scion selfed	0	522	805
92.592.1[1]	92.592.1 scion	0	0	21

[1]Results of this line are for the G_0 (scion) generation.

FOUR-WAY HYBRID SUGARBEETS UTILIZING CYTOPLASMIC MALE STERILITY

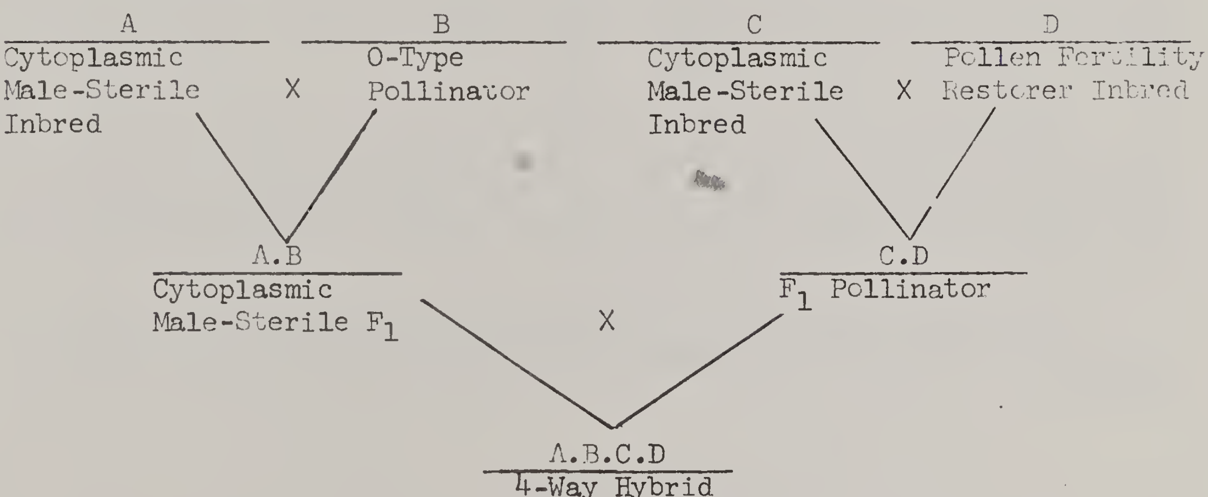
By J. C. Theurer

In 1954 Owen (1) suggested that breeders might find merit in producing a 4-way hybrid sugarbeet variety (AXB) X (CXD). In his proposal, both cytoplasmic and Mendelian types of male sterility were utilized. The A line and the single cross A.B would carry cytoplasmic male sterility and the pollinator B would be of O-type. The grandparent C would be a line heterozygous for the Mendelian male sterility gene and would be rogued to sterile plants in the early stages of flowering. The D pollinator could be from a variety of material, either O-type or non-O-type.

The necessary roguing work during the bud stage to eliminate pollen producers from the segregating C line requires a significant amount of proper timing and effort. This extensive hand labor may not be justifiable for large-scale seed production. At least, it could be one of the major reasons that few 4-way hybrids have been produced for commercial use in the past decade.

Studies conducted this past summer with hybrids derived from cytoplasmic male-sterile lines and a pollen restorer line indicate it now may be feasible to produce a 4-way hybrid utilizing only the cytoplasmic type of male sterility. This is evidenced by the pollen fertility and seed production realized when a pollen restorer (R_f) line is utilized as grandparent D.

The production of the 4-way hybrid is shown schematically below:



Theoretically, lines A and B would be selected so as to have good combining ability with lines C and D or vice versa.

The frequency of lines carrying strong fertility restoring genes is low. However, it appears that O-type lines in most cases could be converted to R_f lines by a 3- to 4-generation backcrossing program (See Table 2).

Pollen fertility readings made on several R_f hybrids are given in Table 1. Plants were visually scored at both St. George, Utah, and Salinas, California, and a sample of pollen from plants at St. George was read microscopically. Several lines had 90-100 percent completely fertile plants. All 20 of the hybrids at each location consisted of fertile or partially fertile offspring. S me plants produced male-sterile flowers, but no single plant was completely sterile. The hybrids involving SL 211H3 and CT9mm had more plants scored as partial fertiles at Salinas than at St. George. SLC 128 X R_f showed the reverse tendency. Of interest was the observation that NB-1 had a low percentage of completely fertile plants at both locations. Thus NB-1 appears to be one of the best, if not the best, emasculator line we have at present.

NB-1 CMS also showed the greatest tendency to resist pollen restoration in another test of the same male-sterile lines crossed to an annual R_f line derived from table beets. Fifteen hybrids in the latter test ranged from 44% to 100% fertile plants, whereas the one involving NB-1 had only 6% completely fertile plants.

A population of 50-60 plants was grown at each location for each line; however, failure to bolt at both locations and curly top incidence at St. George for several lines resulted in rather low numbers of plants reaching the flowering stage.

Microscopic readings made on St. George material and on a few plants grown in the greenhouse at Logan showed a range of 10% to 98% of aceto-carmine stained pollen.

Seed production of R_f hybrids is good, as shown by the 4-way R_f hybrids made this past summer in local insolation plots. (Table 2). The various hybrids produced 1/3 to 4 1/2 pounds of seed per plot with an average of 2 pounds of seed per plant. These 4-way hybrids will be evaluated in the 1966 variety trials.

Subsequent backcrosses to O-type lines are planned for 1966 in an effort to obtain diverse, disease-resistant, high-quality, restorer inbreds.

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TABLE 1. Pollen fertility readings of R_f hybrids at St. George, Utah, and Salinas, California, in 1965

Current No.	Description	St. George, Ut. Number Plants MS	PF	F	% F	Salinas, Calif.(1) Number Plants MS	PF	F	% F
R4129	SL 211H3 X R_f	0	5	30	86	0	24	20	45
R4130	SLC 127 X R_f	0	0	22	100	0	2	7	78
R4131	SLC 129 X R_f	0	0	13	100	0	0	5	100
R4132	SLC 128 X R_f	0	18	7	28	0	1	5	100
R4133	AI-1 X R_f	0	11	17	61	0	3	16	84
R4134	AI-10 X R_f	0	1	2	67	0	1	4	80
R4135	CT9mm X R_f	0	1	23	96	0	7	10	59
R4136	NB-1 X R_f	0	16	5	24	0	11	7	39
R4137	C515 X R_f	0	0	2	100	0	0	17	100
R4138	F54-22-H-14 X R_f	0	1	16	94	0	1	55	89
R4139	S 3317-5 X R_f	0	1	37	97	0	2	27	93
R4140	F.C.502 X R_f	0	0	2	100	0	1	5	83
R4141	S 3317-14 X R_f	0	0	3	100	0	1	22	96
R4142	F.C.503 X R_f	0	2	6	75	0	0	37	100
R4143	308 Hol X R_f	0	1	30	97	0	1	31	97
R4144	2937 X R_f	0	0	31	100	0	0	41	100
R4145	2938 X R_f	0	5	26	84	0	0	35	100
R4146	SLC 126 X R_f	0	0	64	100	0	1	59	98
R4148	SL 0130 X R_f	0	0	55	100	0	1	41	98
R4301	SLC 129 + a X R_f	0	1	28	97	0	0	20	100
R4302	SLC 122 + a X R_f	0	4	13	76	0	0	4	100
R4601	R_f from US201	0	15	7	32	0	0	17	100

(1) Readings at Salinas, California, were made by I.O. Skoyen.

TABLE 2. Seed production (pounds) of 4-way hybrids utilizing cytoplasmic male-sterile and restorer lines.

Female Parent	Male Parent AI-1 X R_f	CT9 X R_f	SLC 128 X R_f	129 X R_f	C515 X R_f
AI-1 X 129	----	(9)[1] 1.25	----	----	(10) 1.00
AI-1 X OV3	----	(10) 2.47	----	(7) 3.25	(10) 3.75
AI-1 X F.C.503	----	(10) 2.50	(9) 1.25	(6) 1.50	(8) 2.00
CT9 X F.C.503	----	----	(6) 2.50	(6) 1.50	(4) 1.25
CT9 X EL31	----	----	(9) 1.25	(9) 1.50	(6) 1.00
127 X 133	(6) 0.77	----	(9) 1.12	----	----
128 X F.C.503	(10) 3.25	(10) 3.00	----	----	----
129 X CT 5A	----	(7) 1.75	----	(9) 2.00	(10) 2.00
129 X OV1	(10) 1.75	(10) 1.50	----	----	----
308 Hol X CT5B	(8) 2.47	(10) 4.29	----	(10) 3.25	----
308 Hol X 129	----	(10) 2.75	----	(10) 2.00	----
308 Hol X 00.5	(7) 0.30	(4) 0.99	(4) 1.10	----	(2) 0.77
3-9 Hol X EL31	----	----	----	(10) 3.75	(7) 2.00
S3317 X F.C.503	(10) 2.50	----	(10) 1.00	----	----
F.C.502 X 00.5	----	----	----	(9) 1.50	(8) 2.00
F.C.503 X CT5B	(10) 3.00	----	----	(9) 2.75	----
AI-1	(10) 0.53[2]	----	----	----	----
CT9	----	(9) 0.67[2]	----	----	----
128	----	----	(10) 0.36[2]	----	----
129	----	----	----	(10) 2.00[2]	----
C515	----	----	----	----	(5) 0.30[2]

1/ Numbers in parentheses refer to the number of plants from which seed was harvested.

2/ B_1 generation seeds.

Crosses and Reciprocal Crosses with the Annual Male-Sterile Tester and its O-Type Pollinator

by J. C. Theurer

The annual male-sterile tester SLC 03 CMS is quite universally used to index pollinators for O-type. While it has proved quite helpful, reports have been made that it doesn't index some pollinators the same as selected biennial CMS lines do. Whether this is due to different genotypes, to different cytoplasms, to environmental factors, or to a combination of these is unknown.

In 1964 seed was produced in isolation of crosses between SLC 03 CMS and diverse pollinators from various sources. Crosses were also made between various biennial CMS lines and the pollinator SLC 03. Where possible this seed production included reciprocal crosses between CMS and pollinator equivalents of the annual and biennial lines.

All of the above crosses were planted in bay 2 of the greenhouse in September 1964 and maintained in a temperature of approximately 70° F. Anthers were collected from each plant and the degree of pollen fertility was determined by microscopic observation of percent aceto-carmine stained pollen.

Results and Conclusions

The results of the crosses to the annual CMS tester are shown in Table 1. Of the 27 pollinators, 13 were O-type, 3 near-O-type, and 11 non-O-type. SLC 129, SLC 128, NB-1, C515, C672, EL 31, EL 32, and EL 33 lines all produced 100% male-sterile progenies as expected. The CT 9 lines produced abundant partial-fertile and fertile segregates. This is of particular interest since CT 9 mm is one of the major inbreds used in the production of commercial hybrids in the intermountain area.

Lines involving CT 9, 00.5, and 8333 pollinators gave sufficient completely fertile offspring to suggest they carry an allele of the dominant "X" gene for pollen fertility. In the other hybrids male-sterile segregates were far more numerous than pollen-producing offspring. (Classes MS and #2 vs. #3, #4 and F) An explanation for this behavior may be that male sterility is dominant to partial fertility in the absence of the "X" gene. Alternatively, a change of some S to N type cytoplasm could be the reason for such lopsided segregations. The data definitely show that white-anther male-sterile plants do not necessarily have the same identical genotype.

Seed was obtained for 24 crosses between biennial CMS lines and the SLC 03 pollinator. Readings of these lines show 13 O-type, 4 near-O-type, and 7 non-O-type segregations (Table 2).

Since SLC 03 CMS is in the seventh generation of backcrossing to the highly inbred (S_{10}) SLC 03, it is expected that the genotypes of the two lines are quite homogeneous.

Ten reciprocal sets of annual SLC 03 CMS and SLC 03 with various biennial lines are shown in Table 3. With one exception there were no reciprocal differences. SLC 129, SLC 128, Ovana, C515, NB-1 and EL 33 all gave 100% male-sterile progenies. SLC 126, SLC 35, and FC 503 produced fertile segregates in reciprocal crosses to the annual lines. CT 9 mm was an exception. When used as a pollinator, a high degree of fertile offspring was obtained, while CT 9 mm CMS X SLC 03 gave 100% male-sterile progeny. The line CT 9 mm CMS was rogued heavily prior to pollination by the SLC 03 parent and may account for some of the reciprocal differences. The results of the other crosses tend to indicate that the CMS lines have similar cytoplasm but carry different modifying genes.

Table 1.--Summary of crosses of annual CMS tester with several biennial pollinators.

Description	Fertility (number plants)				
	MS*	#2	#3	#4	F
SLC 03 CMS X SLC 129	64	0	0	0	0
SLC 03 CMS X SLC 128	116	0	0	0	0
SLC 03 CMS X SLC 132	104	0	0	0	0
SLC 03 CMS X SLC 122-19	132	0	0	0	0
SLC 03 CMS X SLC 122	22	0	0	0	0
SLC 03 CMS X CT 5A	51	0	0	0	0
SLC 03 CMS X Ov. 1	73	1	0	0	0
SLC 03 CMS X Ov. 3	38	0	0	0	0
SLC 03 CMS X C515	21	0	0	0	0
SLC 03 CMS X NB-1	36	0	0	0	0
SLC 03 CMS X C672	64	0	0	0	0
SLC 03 CMS X EL 31	83	0	0	0	0
SLC 03 CMS X EL 32	40	0	0	0	0
SLC 03 CMS X EL 33	45	0	0	0	0
SLC 03 CMS X CT 9A	156	11	0	0	0
SLC 03 CMS X SLC 126	25	11	8	0	2
SLC 03 CMS X Line 289	69	1	1	0	0
SLC 03 CMS X FC 503	3	2	3	0	0
SLC 03 CMS X SLC 35	69	5	2	3	0
SLC 03 CMS X SLC 127	13	4	1	2	4
SLC 03 CMS X 3958 (Sh)	59	2	2	7	9
SLC 03 CMS X 00.5	65	7	4	6	24
SLC 03 CMS X 8333	23	9	16	8	28
SLC 03 CMS X 00.2	20	3	10	29	39
SLC 03 CMS X CT 9B	16	4	39	47	39
SLC 03 CMS X CT 9 mm	5	10	10	14	3
SLC 03 CMS X 5.9	26	9	11	21	31

*MS = White anthers - no stainable pollen
#2 = Very light yellow anthers - none or a trace of stainable pollen
#3 = Yellow anthers 1-25% - non-dehiscent stainable pollen
#4 = Yellow anthers 30-65% - partially dehiscent stainable pollen
F = Yellow anthers 70-98% - dehiscent stainable pollen

Table 2.--Summary of crosses of several biennial CMS lines and SLC O-type annual pollinator.

Description	Fertility (number plants)				
	MS*	#2	#3	#4	F
211H3 X SLC 03	70	0	0	0	0
9134 (7121 X 128) X SLC 03	26	0	0	0	0
SLC 129 X SLC 03	28	0	0	0	0
SLC 128 X SLC 03	31	0	0	0	0
CT 9 mm X SLC 03	44	0	0	0	0
S3317-14 X SLC 03	45	0	0	0	0
308H01 X SLC 03	72	0	0	0	0
C515 X SLC 03	23	0	0	0	0
C562 X SLC 03	13	0	0	0	0
NB-1 X SLC 03	57	0	0	0	0
AI-10 X SLC 03	35	0	0	0	0
EL 33 C-1 X SLC 03	10	0	0	0	0
EL 33 C-2 X SLC 03	51	0	0	0	0
2938 X SLC 03	31	5	0	0	0
NB-5 X SLC 03	47	2	0	0	0
AI-1 X SLC 03	47	1	0	0	0
2935 X SLC 03	29	6	0	0	0
SLC 126 X SLC 03	31	11	1	0	0
2936 X SLC 03	42	5	6	0	0
FC 503 X SLC 03	13	12	4	0	0
2937 X SLC 03	38	2	2	1	0
2934 X SLC 03	23	5	2	1	1
SLC 35 CMS X SLC 03	17	8	6	3	4
F54-22H-14 X SLC 03	30	10	2	1	0

*MS = White anthers - no stainable pollen
#2 = Very light yellow anthers - none to trace of stainable pollen
#3 = Yellow anthers 1-25% - non-dehiscent stainable pollen
#4 = Yellow anthers 30-65% - partial dehiscent stainable pollen
F = Yellow anthers 70-98% - dehiscent stainable pollen

Table 3.--Reciprocal crosses of annual SLC 03 and SLC 03 CMS with various CMS and O-type biennial lines.

Description	Fertility (number plants)				
	MS*	#2	#3	#4	F
SLC 129 CMS X SLC 03	28	0	0	0	0
SLC 03 CMS X SLC 129	64	0	0	0	0
SLC 128 CMS X SLC 03	31	0	0	0	0
SLC 03 CMS X SLC 128	116	0	0	0	0
308H01 X SLC 03	72	0	0	0	0
SLC 03 CMS X Ovana .1	73	1	0	0	0
SLC 03 CMS X Ovana .3	38	0	0	0	0
C-515 CMS X SLC 03	23	0	0	0	0
SLC 03 CMS X C-515	21	0	0	0	0
NB-1 CMS X SLC 03	57	0	0	0	0
SLC 03 CMS X NB-1	36	0	0	0	0
EL 33 C-1 CMS X SLC 03	10	0	0	0	0
EL 33 C-2 CMS X SLC 03	51	0	0	0	0
SLC 03 CMS X EL 33	45	0	0	0	0
FC 503 CMS X SLC 03	13	12	4	0	0
SLC 03 CMS X FC 503	3	2	3	0	0
SLC 126 CMS X SLC 03	31	11	1	0	0
SLC 03 CMS X SLC 126	25	11	8	0	2
SLC 35 CMS X SLC 03	17	8	6	3	4
SLC 03 CMS X SLC 35	69	5	2	3	0
CT 9 mm CMS X SLC 03	44	0	0	0	0
SLC 03 CMS X CT 9 mm	5	10	10	14	3

*MS = White anthers - no stainable pollen
#2 = Light yellow anthers - none or a trace of stainable pollen
#3 = Yellow anthers 1-25% - non-dehiscent stainable pollen
#4 = Yellow anthers 30-65% - partial dehiscent stainable pollen
F = Yellow plump anthers 70-98% - dehiscent stainable pollen

A Study of the Stability of Genetic Male Sterility in Segregating Generations

By J. C. Theurer

Inbred sublines of SLC 128 and other O-type pollinators have frequently shown partial-fertile as well as male-sterile plants in their offspring. The male-sterile plants were expected since these lines are known to carry the Mendelian gene for male sterility. The occurrence of partial male steriles, however, raises the question whether the Mendelian gene a_1 segregates as clear-cut for fertile and male-sterile offspring as Owen originally proposed (1, 2) or if these partial steriles are due to environment. Semi-male steriles have been cited in the past as a distinguishing feature of the cytoplasmic type of sterility.

Methods

During the summer of 1964 a cross was made between a Mendelian male-sterile plant, SLC 129 aa, and the O-type annual pollinator SLC 03 which is homozygous AA. The F_1 generation was observed in the greenhouse December 17-21, 1964, and all plants were fertile, shedding an abundance of pollen. Microscopic readings were made on 15 plants. Of these, 12 were 95%, 2 were 90%, 3 were 80% and 1 was 70% fertile.

Five F_2 lines were planted in peat cups in the greenhouse in June of 1965. After 3 weeks of growth they were transplanted individually to 6-inch fibre pots. During the latter part of August and the early part of September 1965, the annual plants were observed for fertility both visually and microscopically. The biennial segregates were placed in the cold chamber for thermal induction in September.

Results

The results to date are given in Tables 1 and 2. Plants scoring microscopically 10% to 60% aceto-carmine stainable pollen were classed as partial fertiles and 70% to 100% as fertiles.

Six plants were classified as partial fertiles. One might argue that plants with 50% or 60% stainable pollen could be classified as fertile. However, the non-dehiscence of anthers and the abundance of randomly scattered male-sterile flowers are in favor of semi-fertility. Certainly, there would be no argument for the plant with 10% stainable pollen.

When fertiles and partial fertiles are grouped together, they give a good fit to the original single gene hypothesis (Table 2). The few partial fertile plants observed would in no way justify altering the breeder's approach to use of Mendelian male sterility.

The biennial segregates of the original cross will be evaluated in the greenhouse about March 1966.

Literature Cited

1. Owen, F.V. 1945 Cytoplasmically inherited male sterility in sugarbeets. Jour. Agr. Res. Vol 71(10):423-440.

2. __________ 1952 Mendelian male sterility in sugarbeets. Am. Soc. Sugarbeet Tech. Proc. 7: 372-376.

TABLE 1. Frequency distribution (percent) by lower class levels for microscopic pollen fertility of annual progeny of SLC 129 aa X SLC 03 F_2 lines

Current Number	Class Percentage									
	MS	10	20	30	40	50	60	70	80	90
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
B 5520-1	5	0	0	0	0	1	0	0	1	8
B 5520-3	4	0	0	0	0	0	0	0	0	16
B 5520-5	5	1	0	0	0	0	1	0	1	15
B 5520-6	4	0	0	0	0	0	2	0	1	16
B 5520-7	8	0	0	0	0	1	0	1	3	10

TABLE 2. Segregation in F_2 generation annual plants from the cross SLC 129 aa X SLC 03

Current Number	Number Observed			Number Expected			X^2	P
	MS	PF	F	MS	PF	F		
	No.	No.	No.	No.	No.	No.		
B 5520-1	5	1	13	5	0	14	0	1.00
B 5520-3	7	0	21	7	0	21	0	1.00
B 5520-5	8	2	17	7	0	21	0.193	0.60-0.70
B 5520-6	7	2	18	7	0	21	0	1.00
B 5520-7	9	1	15	6	0	19	1.974	0.10-0.20
TOTAL	36	6	83	31.25		93.75	0.96	0.30-0.40

STUDIES TO DETERMINE THE STABILITY OF MENDELIAN MALE STERILITY FACTORS IN SUGARBEET LINES

By C. H. Smith

The study to determine the stability of the male-sterile characters in sugarbeet lines was continued in 1965. The stainable pollen technique, using aceto-carmine as the staining agent, was the preferred method for the determination. Pollen samples were gathered from the first open flowers on the plant. When successive readings were made on the same plant, pollen samples were taken from developing side branches. Plants for selfing or crossing purposes were bagged as the first flowers opened.

Stecklings of the selfed lines were induced in a refrigerated storage chamber and planted in the greenhouse for study. One group was represented in a St. George, Utah, field planting to study the differences in pollen production and fertility between plants grown outdoors and in the greenhouse (Table 1). In the field a single pollen sample was examined from each plant. In the greenhouse studies, pollen samples were gathered from plants at two to four intervals during the flowering period to study the range of variation of pollen fertility. Pollen readings were in agreement in four of the numbers used in the two plantings. Two numbers, S4582-1-5 and S4582-1-21, were highly variable in the field planting, whereas the plants in the greenhouse produced pollen of high fertility. Other numbers grown in the greenhouse produced a variation in pollen fertility readings from male-sterile in early readings to high fertility in later readings. Some plants in these same numbers varied from high to low fertility readings, while others maintained identical readings throughout the flowering period. The wide range of difference in pollen fertility readings in 1964 was thought to be partially due to cool (60°-70° F) greenhouse temperatures maintained during the growth and flowering periods of the plants. Temperatures during 1965 greenhouse studies were maintained between 75° and 85° F. Production of pollen at the warmer temperatures was improved over that produced in cool temperatures. Improvement of seed set was not noticeable when warm temperatures were maintained during seed development. Differences in pollen fertility were noted on flowers on the same branch read the same day, which indicate that variability not only exists between plants but also between flowers of the same plant. More closely controlled environmental and physiological studies may reveal some of the baffling answers.

Stecklings from five lines received from the Utah Idaho Sugar Company and reported to be aa hybrids which gave unexpected fertility ratios were planted in the greenhouse. A wide range of pollen fertility was observed in this material (Table 2). At least two

readings were made per plant - one from the earliest flowers to open and a second reading from flowers on later maturing branches of the plant. Although the lines tested may not have been from the same seed lots as those tested by the Utah Idaho Sugar Company, they were very closely related material and similar ratios of male sterility to fertility could be expected. The ratio of male sterility to fertility in the F_1 generation should be either 1:1 or all fertile. In the Utah Idaho Sugar Company test three crosses (110 aa X SP 571-0, 110 aa X CT 9, and 110 aa X 112) produced more male steriles than could be explained on the basis of chance alone. In our tests these three crosses produced a greater percentage of partial fertility and a medium percentage of male sterility in the first reading. In the second reading the shift seemed to be to an increase of fertiles and corresponding decrease of male steriles. In the sugar company tests, the two crosses, CT 5 X CT 4 and CT 5 X CT 9, produced more fertile plants than could be expected by chance alone, having no plants in the partial male-sterile group and very few male steriles. In the Logan tests the tendancy of these two crosses were very much the same with a slight shift from the male-sterile to the fertile group in the second pollen reading.

Anther dehiscence was observed to be an important factor in some progeny, which made it extremely difficult to obtain pollen for readings. In some instances only small amounts of pollen were obtained, and of the grains present, most were stainable and of normal size. Anther dehiscence was variable among plants of the same progeny and may or may not change on the same plant during the flowering period.

TABLE 1. Comparative pollen fertility readings of greenhouse and field-grown plants

Current Number	Old Number	Logan greenhouse planting: Reading Number	MS	PF	F	St. George field planting: MS	PF	F
S4582-1-5	S3582-1	1	1	0	8	7	22	14
		2	1	0	8			
S4582-1-9	do	1	0	0	4	0	4	4
		2	0	0	4			
S4582-1-16	do	1	2	1	15	3	3	16
		2	1	1	16			
S4582-1-20	do	1	1	0	25	1	2	24
		2	0	1	25			
S4582-1-21	do	1	0	0	6	21	22	45
		2	0	0	6			
S4582-4 5	S3582-4	1	0	18	21	0	[illegible]	5
		2	0	18	21			

TABLE 2. Fertility readings on male-sterile numbers from Utah Idaho Sugar Company

Current Number	Old Number	Stainable pollen reading in percent: First Reading: MS	PF	F	Second Reading: MS	PF	F
A 3940	110 aa X SP571-0	31.3	62.5	6.2	3.4	48.3	48.3
A 3941	110 aa X CT 9	24.5	67.9	7.6	17.1	53.6	29.3
A 3942	110 aa X 112	24.7	26.0	49.3	5.0	26.7	68.3
A 3943	CT 5 aa X CT 4	6.6	9.9	83.5	2.1	6.4	91.5
A 3944	CT 5 aa X CT 9	2.4	7.1	90.5	0.0	10.9	89.1

Variety Test, Logan, Utah, 1965
by G. K. Ryser

Tests 1 and 5

Tests 1 and 5 consisted of 145 single-cross hybrids representing 16 CMS females and 25 pollinators from a wide base representing most sugarbeet growing areas in the U.S. Insufficient seed for planting nine replications of every single cross necessitated dividing the hybrids into two tests: Test 1, a balanced lattice with 64 crosses and nine replications, and Test 5, a partially balanced lattice with three replications and 81 crosses. The means reported in Tables 1 and 5 are the adjusted means.

Variety 41250, the combination with S3317 CMS and Ov. 3 pollinator (from SL 630 hybrid S_2 sister lines) produced the highest gross sugar in the test with 28.51 tons beets per acre, 16.31 percent sucrose and an average impurity index of 425 (Table 1). This hybrid was not significantly different in gross sugar yield from 41448 (CT 9 mm X 3611 (ud)). Hybrids involving the latter pollinator (2_a Udycz, a selection received from Poland in 1959) also produced an excellent percentage of sucrose with above average tons per acre in 1964. None of the other varieties of the first 10 of Test 1 are significantly different than the check variety 1114 in gross sugar or sucrose. The high producing qualities of Ov. 3, Ov. 1, and 3611 (ud) also hold for Test 5. Varieties 41241 (SLC 128 X Ov. 3) ranked first, 41445 (SLC 129 X 3611 (ud)) ranked second, 41446 (SLC 128 X 3611 ud) ranked fourth, and 41390 (NB-1 X Ov.1) ranked fifth in gross sugar (Table 5). The data indicate that SLC lines are quite closely related and show better yields when they are outcrossed to inbreds of diverse genotype.

The specific and apparent general combining ability for three CMS females and nine pollinators in Test 1 are shown in Table 1A for percent sucrose and tons beets per acre and Table 1B for pounds gross sugar per acre and impurity index. An LSD 5-percent point for gross sugar was estimated to be 519 pounds with a significant F value between pollinators. For sucrose percent the estimated LSD 5-percent point was 0.67 with a significant F value for females only. The estimated LSD 5-percent point for tons per acre was 2.07 and for impurity index 62 with significant F values for both females and males. There were no significant differences for specific combining ability.

Tables 1C and 1D give an indication of the specific and apparent general combining ability with 7 CMS females and 11 pollinators of tests 1 and 5 for percent sucrose, tons beets per acre, gross sugar, and impurity index.

The general combining ability of the pollinators 3611 (ud) and Ov. 3 are evident as to sucrose and tons per acre. The combining of treatments of two tests with different numbers of replications and different treatments are not necessarily valid but can be used for an indication.

Curly top resistance for entries in Tests 1, 2, and 3, is given by A. M. Murphy, page 102.

VARIETY TEST, LOGAN, UTAH, 1965
by G. K. Ryser

SOIL TYPE: Silty clay loam

PREVIOUS CROPS: Alfalfa 7 years; 1961, safflower; 1962, beets; 1963, grain; 1964, safflower.

FERTILIZERS: 400# of ammoniated phosphate (20-40) per acre broadcast and harrowed in the spring before planting.

PLANTED: May 3-4, 1965.

THINNED: June 4-5, 1965.

IRRIGATIONS: Before thinning, sprinkled as needed. Weekly sprinklings after thinning beginning June 7, 1965.

CURLY TOP: Symptoms were noted in susceptible varieties only.

HARVESTED: Oct. 11-15, 1965. Tops were removed with a roto-beater and scalped with a tractor-mounted scalping tool supplemented by long-handled hoe trimming, to assure a complete topping job. A ten-beet sample from each row of each plot was obtained for sugar analysis. All beets were counted and weighed to determine beet stand and acre yield, respectively.

EXPERIMENTAL DESIGN: Plots of all tests were two rows wide, 22 inches apart, with a harvested plot length of forty feet.

Test 1 - An 8X8 balanced lattice with 9 replications consisting of 64 experimental CMS hybrids. Parent lines were from USDA, U. S. sugar companies, and local sources. The pollinators are represented in Test 3.

Test 2 - A randomized block with 6 replications made up of 16 of the highest yielding hybrids of the 1964 test.

Test 3 - A 5X5 balanced lattice square with three replications. The 25 inbred varieties were pollinators used in experimental hybrids of Test 1 and Test 5.

Test 4 - A six-replicate randomized block experiment consisting of 7 sugar selections from 0198 (SLC 125 X Group A nematode selections.) Two entries were seed increases of beets selected individually for high sugar, while five were seed increases of low-sugar selections.

Test 5 - A 9X9 triple lattice with 3 replications. The 81 experimental hybrids are from the same lines as in Test 1 but include hybrids with insufficient seed for inclusion in the 9 replication test.

Test 2

Six of the hybrids that were among the first ten in gross sugar yield in 1964, together with two varieties (31943 and 31980) having 3611 (ud) as pollinator and the two check varieties 1114 and 1101, were replanted in Test 2 in 1965. Test 2 also included six varieties (31940-1, 31945-1, 31968-9, 31939-9, 31976-7 and 31976-1) representing each female that was highest in gross sugar yield in its respective female group of Test 2 in 1964 (Table 1, 1964).

Hybrid 311004-9, which carries Janasz cytoplasm crossed with S_2 pollinator lines from the SL 630 Ovana hybrid, had the top gross sugar, significantly topping all hybrids in 1965 except hybrid 31980. This line was also best in gross sugar yield, tons per acre, and sucrose percent (Table 2).

Table 2A shows the combined data for the two years. The difference between years is highly significant in gross sugar, tons per acre, and impurity index for varieties in Test 1, 1964, compared to the same varieties in Test 2, 1965. This comparison also gave significant interactions (varieties X years) in gross sugar and tons beets per acre, but not in percent sucrose and impurity index. When comparing varieties in Test 2 of 1964 with Test 2, 1965, the only significance was between varieties.

Test 3

Test 3 is made up of the pollinators used in single-cross hybrids of Test 1 and Test 5 representing a wide base of inbred material. Highest yielding lines 3611 (ud), CT 5B and 00.5 are not significantly different in gross sugar from other lines until compared with line Ov. 1 (ranked 9). They are significantly different, however, when ranked as to tons per acre, sucrose percent, and impurity index. The high tons per acre of line 00.5, which is a nematode selection from American Crystal material, could be due to the single generation of inbreeding.

The outstanding sucrose percent (18.67) and comparative high tons per acre (20.61) of 3611 (ud) shows the possibilities of this number as pollinator when compared with their hybrids in Tests 1 and 5 (Tables 1 and 5).

The stands in Test 3 may have affected the performance of some lines since they had very poor emergence under excellent spring conditions.

The first nine hybrids of Test 1, ranked by gross sugar, were represented by pollinators of Test 3 in the following order: Ov. 3, 3611 (ud), Ov. 3, CT 9A, Ov. 3, Ov. 3, Ov. 1, EL 32, and EL 32. Three of these inbreds (3611 (ud), CT 9A and Ov. 1) are among the first ten lines of Test 3. Ovana 3 is ranked 19th in Test 3 while EL 32 ranked 14th. These two numbers showed more general combining ability, being represented so may times among the high-producing single-cross hybrids.

Test 4

Hybrid 0198 has, as the CMS female parent, SLC 129 and, as pollinator, a group of selected nematode numbers derived from material sent to us in 1956 by the American Crystal Sugar Company.

A high-sugar selection of 0198, made in 1963, was grown in isolation in 1964 on the South Farm of Utah State University,Logan, Utah, and consisted of 6 individual beets (4 fertile and 2 male sterile). The individual plants in the isolation were analyzed as follows:

Beet No.	Weight	Sucrose	N	Na	K	Impurity index
404 F	1080	15.8	153	71	1257	311
323 F	920	16.0	182	110	935	284
335 F	780	16.3	134	68	1331	201
310 MS	1080	15.7	48	78	1144	231
294 MS	1000	15.1	115	105	1229	304
346 F	1100	15.5	105	154	1331	317

The seed from each plant was harvested separately. The two high-sugar numbers planted in Test 4 consisted of 4702, a fertile plant 404, and 4713S, a sib from male-sterile plant 294 (Table 4).

A low-sugar group was grown in another isolation in Northern Cache Valley. Of the 5 beets that survived transplanting, only one, 342, was classified as partially fertile. All the rest were male sterile. These selections gave individual beet analyses as follows:

Beet No.	Weight	Sucrose	N	Na	K	Impurity index
313 MS	930	14.4	29	26	1172	245
326 MS	1160	12.3	86	116	1257	451
342 PF	1980	14.0	259	205	1912	578
366 MS	910	13.4	115	140	1566	415
383 MS	1100	13.0	125	114	1566	428

Seed increases from all five low-sugar beets was planted in Test 4.

Variety 4702, a high-sugar selection, was significantly better than any other selection in gross sugar, tons per acre, sucrose, and impurity index (Table 4). Variety 4711S from beet 326, a low-sugar selection, unexpectedly placed next, but was not significantly greater than variety 4713S from beet 294, the other high-sugar selection. Variety 4713S is significantly higher than 4709S and 4710S, the two lowest yielders in the test. Beet 326, having low Na, amino N, and comparatively low impurity index, combined with the comparatively high values of the pollinator beet 342 giving the high yield and high sucrose of variety 4711S.

The long petioles and luxuriant top growth of the two high-sugar selections, when compared with the top growth of the low-sugar selections, was apparent throughout the growing season.

Table 1.--Variety test 1, North Farm, Logan, Utah, 1965

64 varieties, 9 replications of each variety. Balanced lattice. Adjusted means

Vari-				ACRE YIELD			Impur-	PPM			
ety code	Current number	Description	Rank	Gross sugar	Tons beets	Percent sugar	ity index	Amino N	Na	K	Beet count
14	41250	S3317 X Ov. 3	1	9295	28.51	16.31	425	293	114	1440	95
6	41448	CT 9mm X 3611 (ud)	2	9096	25.45	17.88	373	193	102	1735	80
26	41245	NB-1 X Ov. 3	3	8860	27.59	16.09	420	201	133	1720	84
38	41278	308H01 X CT 9A	4	8748	29.02	15.12	521	260	160	1868	85
5	41246	CT 9mm X Ov. 3	5	8733	27.46	15.92	428	223	137	1623	92
3	41240	SLC 129 X Ov. 3	6	8718	26.94	16.16	399	241	111	1458	90
59	41388	SLC 129 X Ov. 1	7	8710	27.36	15.90	353	182	101	1381	87
41	41406	S3317 X EL 32	8	8615	27.04	15.96	421	213	117	1635	84
50	41402	308H01 X EL 32	9	8594	31.22	13.79	585	221	244	1994	86
23	1114	Check	10	8567	26.74	16.04	355	180	106	1398	88
32	01463	1104 X EL 31	11	8439	25.53	16.55	355	212	101	1352	89
49	41242	AI-1 X Ov. 3	12	8392	25.55	16.43	410	275	122	1415	95
4	41399	SLC 129 X EL 32	13	8391	26.20	16.01	400	183	115	1657	87
64	41430	CT 9mm X 00.5	14	8364	27.17	15.37	477	191	141	1947	90
34	04112	0130 X C672	15	8341	25.80	16.18	391	183	102	1648	89
58	04106	308H01 X C672	16	8310	28.75	14.48	625	306	143	2173	86
43	04166	0177 X EL 31	17	8302	24.86	16.72	390	257	79	1460	85
27	41161	SLC 35 X CT 5B	18	8270	25.21	16.44	363	167	88	1573	95
55	41401	AI-1 X EL 32	19	8254	25.99	15.95	391	187	119	1549	88
51	41162	SLC 129 X CT 5	20	8245	25.15	16.37	335	186	82	1343	94
40	41385	SLC 128 X Ov. 1	21	8240	25.88	15.96	384	196	115	1483	85
7	04156	SLC 129 X EL 31	22	8217	24.91	16.51	342	203	74	1334	91
57	04157	SLC 128 X EL 31	23	8214	24.73	14.61	363	217	97	1363	90
54	41387	308H01 X Ov. 1	24	8205	28.05	14.67	578	271	170	2030	91

Variety Test 1, Table 1 continued

Vari- ety code	Current number	Description	Rank	ACRE YIELD Gross sugar	ACRE YIELD Tons beets	ACRE YIELD Percent sugar	Impur- ity index	PPM Amino N	PPM Na	PPM K	Beet count
52	41306	NB-1 X CT 9B	25	8178	25.53	16.02	375	197	106	1468	83
47	41441	0130 X 00.5	26	8173	26.74	15.29	459	189	154	1830	94
21	41427	SLC 128 X 00.5	27	8156	26.43	15.46	445	199	150	1730	91
30	41118	NB-1 X SLC 128	28	8110	25.87	15.72	379	181	98	1505	84
39	41121	308H01 X SLC 128	29	8101	28.41	14.28	517	227	157	1814	89
19	41451	308H01 X 3611 (ud)	30	8087	25.33	15.97	494	230	145	2037	84
42	41438	0178 X 00.5	31	8061	25.83	15.60	462	177	147	1956	97
9	04161	CT 9mm X EL 31	32	8034	24.74	16.28	384	192	97	1597	86
61	41105	SLC 35 X SLC 128	33	8016	25.08	16.00	325	155	95	1315	88
48	41428	AI-1 X 00.5	34	8013	27.42	14.62	557	221	197	2078	91
37	04167	308H01 X EL 31	35	7992	27.22	14.69	577	302	169	1937	89
10	41431	NB-1 X 00.5	36	7935	25.15	15.78	493	238	124	1969	85
18	41434	S3317 X 00.5	37	7905	26.08	15.16	480	236	136	1769	89
24	41169	308H01 X CT 5B	38	7901	27.46	14.39	510	214	134	1874	89
44	41426	SLC 129 X 00.5	39	7885	25.84	15.26	493	223	163	1865	92
28	04160	0130 X EL 31	40	7872	24.42	16.14	344	183	124	1305	89
56	41170	S3317 X CT 5B	41	7871	24.26	16.20	326	161	82	1344	92
2	04159	0178 X EL 31	42	7850	23.69	16.54	328	171	75	1411	89
16	04110	0177 X C672	43	7795	23.25	16.75	390	190	61	1762	86
29	41394	SLC 35 X Ov. 1	44	7758	23.47	16.52	380	218	105	1489	90
11	41163	AI-1 X CT 5B	45	7753	24.22	16.02	329	167	88	1302	91
36	41357	SLC 129 X CT 5B	46	7747	23.67	16.37	341	183	91	1365	81
13	04101	SLC 129 X C672	47	7643	23.36	16.33	404	193	76	1766	78
35	41201	SLC 129 X SLC 35	48	7640	24.13	15.81	376	165	89	1583	89

Variety Test 1, Table 1 concluded

Variety code	Current number	Description	Rank	ACRE YIELD Gross sugar	ACRE YIELD Tons beets	ACRE YIELD Percent sugar	Impurity index	PPM Amino N	PPM Na	PPM K	Beet count
63	41433	308H01 X 00.5	49	7548	28.30	13.37	779	312	215	2577	94
25	41157	SLC 35 X CT 9B	50	7472	22.49	16.60	357	152	96	1620	80
60	04103	AI-1 X C672	51	7467	23.47	15.92	421	180	88	1830	83
22	41211	308H01 X SLC 35	52	7455	26.81	13.91	621	232	193	2213	84
45	04111	0178 X C672	53	7439	22.57	16.49	375	162	53	1736	90
12	41114	AI-1 X SLC 128	54	7406	23.98	15.47	363	193	101	1330	87
33	41435	SLC 35 X 00.5	55	7379	25.23	14.61	557	203	155	2219	91
8	41123	0130 X SLC 128	56	7377	23.66	15.58	350	170	107	1354	93
17	41147	SLC 129 X CT 9B	57	7351	22.77	15.93	340	149	73	1456	82
1	41302	AI-1 X CT 9B	58	7172	23.53	15.26	396	203	91	1462	85
31	41112	SLC 129 X SLC 128	59	7072	22.30	15.88	349	186	89	1337	87
46	41203	AI-1 X SLC 35	60	7069	22.29	15.85	335	151	94	1392	87
53	41117	CT 9mm X SLC 128	61	7037	22.04	15.98	373	180	83	1539	74
15	41259	0130 X Ov. 3	62	7009	22.61	15.49	358	163	122	1397	85
62	41156	S3317 X CT 9B	63	6961	22.23	15.68	353	169	88	1397	87
20	41122	S3317 X SLC 128	64	6045	19.76	15.26	353	189	96	1267	86
General mean of all varieties				7965	25.36	15.75	421	204	117	1637	88
S. E. of mean				169.17	0.51	0.15	18.70	14.09	8.46	46.06	2.08
Significant difference				471	1.43	0.41	52	39	24	128	6
% coefficient of variation				6.37	6.06	2.78	13.33	20.73	21.74	8.44	7.10
Calculated F values (adjusted)				11.66	16.66	30.33	23.85	7.54	19.47	38.44	4.34

Significant F 5% = 1.38 1% = 1.57

Table 1A.--Specific and apparent general combining ability for percent sucrose and tons per acre for 9 pollinators and 3 CMS lines in Test 1, 1965.

Pollinator	SLC 129 CMS	AI-1 CMS	308H01 CMS	Mean	Rank
		Sucrose			
C672	16.33	15.92	14.48	15.58	4
SLC 128	15.88	15.47	14.28	15.21	7
SLC 35	15.81	15.85	13.91	15.19	8
EL 32	16.01	15.95	13.79	15.25	6
00.5	15.26	16.44	13.37	15.02	9
EL 31	16.51	15.81[1]	14.69	15.68	2
Ov. 3	16.15	16.43	15.23[1]	15.94	1
CT 5A	16.37	16.02	14.39	15.59	3
Ov. 1	15.90	15.65[1]	14.67	15.41	5
Mean	16.02	15.95	14.31		
Rank	1	2	3		
		Tons per Acre			
C672	23.36	23.47	28.75	25.19	7
SLC 128	22.30	23.98	28.41	24.89	8
SLC 35	24.13	22.29	26.81	24.41	9
EL 32	26.20	25.99	31.22	27.80	1
00.5	25.84	27.42	28.30	27.18	3
EL 31	24.91	25.39[1]	27.22	25.84	5
Ov. 3	26.94	25.55	27.28[1]	26.59	4
CT 5A	25.15	24.22	27.64	25.68	5
Ov. 1	27.36	26.21[1]	28.05	27.20	2
Mean	25.13	24.94	28.18		
Rank	2	3	1		

[1]Estimated by average of the females and males for the cell.

Table 1B.--Specific and apparent general combining ability for gross sugar and impurity index for 9 pollinators and 3 CMS lines in Test 1, 1965.

Pollinator	SLC 129 CMS	AI-1 CMS	308H01 CMS	Mean	Rank
		Gross Sugar			
C672	7643	7467	8310	7806	7
SLC 128	7072	7406	8101	7526	8
SLC 35	6640	7069	7455	7387	9
EL 32	8391	8254	8594	8412	3
00.5	7685	8013	7548	7815	6
EL 31	8217	7935[1]	7992	8048	4
Ov. 3	8718	8392	8284[1]	8465	1
CT 5A	8245	7753	7901	7966	5
Ov. 1	8710	8112[1]	8205	8342	2
Mean	8058	7822	8043		
Rank	1	3	2		
		Impurity Index			
C672	405	421	625	484	8
SLC 128	349	363	517	410	3
SLC 35	376	335	621	444	4
EL 32	400	391	585	460	6
00.5	493	557	779	610	9
EL 31	342	428	577	449	5
Ov. 3	399	410	502	437	2
CT 5A	335	329	510	391	1
Ov. 1	353	434[1]	578	455	7
Mean	384	408	588		
Rank	1	2	3		

[1]Estimated by average of the females and males for the cell.

Table 1C.--Specific and apparent general combining ability for percent sucrose and tons per acre for 11 pollinators and 7 CMS lines in Tests 1 and 5, 1965.

Pollinator	SLC 129 CMS	AI-1 CMS	308H01 CMS	NB-1 CMS	S3317 CMS	SLC 128 CMS	CT 9mm CMS	Mean	Rank
				Percent Sucrose					
C672	16.33	15.92	14.48		15.60*	15.70*	15.98*	15.67	6
SLC 128	15.88	15.47	14.28	15.72	15.26	14.75*	15.98	15.33	10
EL 32	16.01	15.95	13.79	15.47*	15.96	---	15.00*	15.36	9
00.5	15.26	16.44	13.37	15.78	15.16	15.46	15.37	15.26	11
EL 31	16.51	15.52*	14.69	15.53*	15.79*	16.61	16.28	15.83	3
Ov. 3	16.15	16.43	---	16.09	16.31	15.26*	15.92	16.03	2
CT 5B	16.37	16.02	14.39	15.62*	16.20	15.85*	15.56*	15.72	5
Ov. 1	15.90	---	14.67	15.55*	15.55*	15.96	15.62*	15.54	7,8
3611 (ud)	17.00*	16.83*	15.97	---	17.05*	17.30*	17.88	17.00	1
CT 9B	15.63*	15.26	---	16.02	15.15*	15.05*	16.13*	15.54	7,8
FC 503	15.88*	15.85*	---	15.17*	15.98*	15.78*	15.83*	15.75	4
Mean	16.08	15.97	14.46	15.66	15.81	15.77	15.96	15.72	
Rank	1	2	7	6	5	4	3		
				Tons per Acre					
C672	23.36	23.47	28.75		26.13*	25.20*	23.67*	25.10	6
SLC 128	22.30	23.98	28.41	25.87	19.76	21.77*	22.04	23.45	10
EL 32	26.20	25.99	31.22	27.67*	27.04	---	27.23*	27.56	1
00.5	25.80	27.42	28.30	25.15	26.08	26.43	27.17	26.63	3,4
EL 31	24.91	25.40	27.22	24.77*	25.13*	24.73	24.74	25.27	5
Ov. 3	26.94	25.55	---	27.59	28.51	25.84*	27.46	26.98	2
CT 5B	25.15	24.22	27.64	22.97*	24.26	22.57*	26.07*	24.70	8
Ov. 1	27.36	---	28.05	27.67*	24.83*	25.88	25.97*	26.63	3,4
3611 (ud)	26.70*	24.33*	25.33	---	24.43*	22.07*	25.45	24.72	7
CT 9B	22.67*	23.53	---	25.53	24.10*	21.77*	25.57*	23.86	9
FC 503	21.03*	21.63*	---	26.13*	20.30*	22.03*	22.67*	22.30	11
Mean	24.77	24.55	28.12	25.93	24.59	23.83	25.27	25.19	
Rank	4	6	1	2	5	7	3		

*Lines in test 5 (unadjusted mean)

Table 1D.--Specific and apparent general combining ability for gross sugar and impurity index for 11 pollinators and 7 male-sterile lines in Tests 1 and 5, 1965.

Pollinator	SLC 129 CMS	AI-1 CMS	308H01 CMS	NB-1 CMS	S3317 CMS	SLC 128 CMS	CT 9mm CMS	Mean	Rank
				Gross Sugar					
C672	7643	7467	8310	---	8147*	7910*	7590*	7844	7
SLC 128	7072	7406	8101	8110	6045	6422*	7037	7170	10
EL 32	8391	8254	8594	8551*	8615	---	8180*	8431	3
00.5	7885	8013	7548	7935	7905	8156	8364	7972	6
EL 31	8217	7882*	7992	7685*	7901*	8214	8034	7989	5
Ov. 3	8718	8392	---	8869	9295	8940*	8733	8770	1
CT 5B	8245	7753	7901	7165*	7871	7153	8099*	7741	8
Ov. 1	8710	---	8205	8610*	7714*	8240	8107*	8226	4
3611 (ud)	9077*	8208*	8087	---	8221*	8718*	9096	8538	2
CT 9B	7100*	7172	---	8178	7302*	6558*	7282*	7325	9
FC 503	6680*	6854*	---	7930*	6493*	6955*	7176*	7089	11
Mean	7975	7740	8092	8114	7783	7727	7972	7907	
Rank	3	6	2	1	5	7	4		
				Impurity Index					
C672	405	421	625	---	487*	435*	421*	466	9
SLC 128	349	363	517	379	353	390*	373	389	2,3
EL 32	400	391	585	508*	421	---	534*	473	10
00.5	493	557	779	493	480	445	477	532	11
EL 31	342	547*	577	486*	579*	363	384	464	8
Ov. 3	399	410	---	420	425	419*	428	427	7
CT 5B	335	329	510	389*	326	338*	363*	370	1
Ov. 1	353	---	578	409*	417*	384	366*	418	6
3611 (ud)	442*	438*	494	---	417*	329*	373	416	5
CT 9B	350*	396	---	375	476*	366*	373*	389	2,3
FC 503	352*	401*	---	526*	334*	356*	368*	390	4
Mean	384	425	583	443	426	383	405	432	
Rank	2	4	7	6	5	1	3		

*Lines in test 5 (unadjusted mean)

Table 2.--Variety test 2, North Farm, Logan, Utah, 1965

16 varieties, 6 replications of each variety. Randomized blocks.

Code	Variety Number	Description	ACRE YIELD Gross Sugar	Tons Beets	Percent Sugar	Impurity Index	PPM Amino N	Na	K	Beet Count
10	311004-9	SLC 35 X 630-9	8758	27.22	16.10	563	393	139	1853	86
16	31980	(3132 X CT 5) X 3611 (ud)	8408	25.83	16.27	460	242	154	1807	71
3	31940-1	(7121 X CT 5) X 630-1	8159	26.38	15.45	496	303	149	1647	86
6	31968-9	(129 X Nema.) X 630-9	8123	26.83	15.15	550	310	147	1888	86
14	31960-9	(AI-1 X 130) X 630-9	8119	26.60	15.26	548	335	161	1781	81
1	31998-1	NB-1 X 630-1	8106	25.95	15.62	510	330	110	1711	70
15	1114	9132 X CT 5	7941	26.72	14.86	474	239	143	1645	89
9	31943	(133 X CT 5) X 3611 (ud)	7699	23.92	16.10	424	227	152	1589	79
13	31976-7	(Ov. X m'm') X 630-7	7574	26.07	14.53	606	351	185	1847	78
12	31968-9	(129 X Nema.) X 630-9	7573	24.68	15.33	465	276	109	1593	85
7	31945-1	(SLC 130 X 289) X 630-1	7510	23.62	15.90	554	438	148	1563	75
4	31976-1	(Ov. X m'm') X 630-1	7493	26.00	14.42	615	344	201	1882	87
2	31939-9	(7121 X CT 5) X 630-9	7472	24.03	15.54	478	289	132	1626	79
5	31955-9	[(AI-1 X 10) X 129] X 630-9	7301	23.50	15.53	496	296	138	1704	74
11	1101	(129 X CT 5) X (630 X CT 5)	7262	25.10	14.47	512	273	171	1603	81
8	311004-1	SLC 35 X 630 S_2-1	7183	23.37	15.40	478	272	150	1613	78
General mean of all varieties			7792	25.36	15.37	514	307	149	1709	80
S. E. of mean difference			253	0.6895	0.24	41	39	15	89	3.50
Significant difference			596	1.39	0.48	82	78	30	179	7
% coefficient of variation			5.62	4.70	2.71	13.83	22.05	17.63	9.04	7.49
Calculated F values			6.40	7.39	11.56	3.40	4.20	4.90	3.40	5.70

Significant F 5% = 1.84 1% = 2.35

Table 2A.--Comparison of unadjusted means of the same varieties in 1964 and 1965.

Variety	Gross sugar 1964	Gross sugar 1965	Gross sugar Mean	Tons per acre 1964	Tons per acre 1965	Tons per acre Mean	Sucrose 1964	Sucrose 1965	Sucrose Mean	Impurity index 1964	Impurity index 1965	Impurity index Mean
From Test 1, 1964 and Test 2, 1965												
311004-9 1/	5967	8758	7163	18.35	27.22	22.15	16.15	16.10	16.13	471	563	510
31998-1	5902	8106	6867	18.96	25.95	21.96	15.36	15.62	15.59	435	510	467
31955-9	5523	7301	6285	17.94	23.50	20.32	15.37	15.53	15.23	484	496	498
31968-9	5496	8123	6633	18.00	26.83	21.79	15.10	15.15	15.12	565	550	559
311004-1	5396	7183	6162	17.59	23.37	20.06	15.21	15.40	15.29	508	478	495
31960-9	5237	8119	6472	17.06	26.60	21.15	15.23	15.26	15.25	491	548	515
1114	5040	7941	6285	17.20	26.72	21.04	14.93	14.86	14.90	446	474	458
1101	5062	7262	6005	17.25	25.10	20.61	14.59	14.47	14.54	504	512	507
31943	4518	7699	5947	15.24	23.92	18.39	15.66	16.10	15.85	393	424	406
31980	4857	8408	6379	15.26	25.83	19.79	15.77	16.27	15.99	421	460	437
Gen. mean all var. 2/	4752	7792	6410	15.60	25.36	20.73	15.05	15.37	15.39	491	514	484
S. E. mean	252	253	296	0.74	0.69	0.52	0.19	0.24	0.15	23	41	18.82
Sig. diff.	704	596		2.05	1.39		0.53	0.48	0.43	64	82	53.00
Calc. F Value	7.39**	6.4**		8.00**	4.70*		6.78**	2.71*	11.03**	3.45**	3.4*	6.00**
From Test 2, 1964 and Test 2, 1965												
31968-9 1/	7289	7573	7431	24.6	24.68	24.64	14.9	15.33	15.12	604	465	535
31976-7	6778	7574	7176	23.9	26.07	24.99	14.1	14.53	14.34	644	606	625
31940-1	6631	8159	7395	21.7	26.38	24.04	15.3	15.45	15.38	470	496	483
31939-9	6596	7472	7034	21.3	24.03	22.67	15.5	15.54	15.52	448	478	463
31976-1	6580	7493	7937	21.9	26.00	23.95	15.0	14.42	14.71	554	615	585
31945-1	6281	7510	6896	20.7	23.62	22.16	15.2	15.90	15.55	525	554	540
Gen. mean all var. 2/	6011	7792	7167	20.14	25.36	23.76	14.87	15.37	15.10	529	514	336
S. E. mean	278	253	127	0.87	0.69	0.49	0.28	0.24	0.10	33	41	15
Sig. diff.	786	596	360	2.47	1.39	1.38	0.79	0.48	0.28	94	82	43
Calc. F Value	3.75*	6.4**	3.72*	5.60**	4.70*	4.70*	4.71**	2.71*	26.60**	4.51**	3.4*	15.83**

1/ See Table 2 for descriptions.
2/ General Mean and S.E. for test varieties are from respective 1964 and 1965 tests.

* = Significant at 5% ** = Significant at 1*

Table 3.--Variety Test 3, North Farm, Logan, Utah, 1965

25 varieties, 3 replications
Analyzed as partially balanced lattice. Adjusted means.

Code	Var. No.	Description	Rank	ACRE YIELD Gross Sugar	ACRE YIELD Tons Beets	ACRE YIELD Percent Sugar	Impurity index	PPM Amino N	PPM Na	PPM K	Beet Count
25	4630	3611 (ud)	1	7528	20.61	18.67	311	178	96	1404	79
19	4624	CT 5B	2	7518	24.19	15.66	344	156	100	1390	82
24	4629	00.5	3	7240	25.82	14.02	686	251	221	2511	81
16	4621	m'm'	4	6618	23.16	14.36	659	214	262	2523	74
10	4611	00.2	5	6612	21.73	15.39	475	225	118	1818	70
14	4617	CT 9A	6	6460	19.44	16.44	343	202	109	1300	66
20	4625	NB-1	7	6451	21.69	14.62	521	232	129	1967	74
12	4613	SLC 35	8	6239	21.24	14.57	426	145	126	1736	79
21	4626	Ov. 1	9	5367	17.42	15.60	420	251	110	1425	64
6	4606	SLC 128	10	5294	17.73	14.92	376	161	84	1497	75
3	4602	SLC 129	11	5223	17.79	14.80	424	174	102	1666	76
7	4607	Line 289	12	5201	15.93	16.73	519	472	89	1394	62
23	4628	SLC 122	13	5020	17.62	14.49	375	168	108	1334	68
22	4627	EL 32	14	4870	17.19	13.96	594	178	387	2097	68
15	4618	SLC 133	15	4850	18.51	12.83	794	359	258	2316	35
9	4610	CT 5A	16	4837	17.49	14.16	428	195	157	1372	61
11	4612	EL 33	17	4649	15.93	14.63	448	206	164	1541	68
17	4622	(CT5 X CT9)⊗	18	4596	15.40	14.68	337	148	83	1269	72
13	4615	Ov. 3	19	4385	13.24	15.75	502	358	174	1546	64
8	4609	CT9	20	4184	13.46	15.53	376	154	67	1618	59
5	4604	FC 503	21	3763	13.30	14.23	385	142	78	1507	65
1	4600	C672	22	3528	10.40	16.63	342	168	46	1562	73
2	4601	C507	23	3138	11.19	14.38	461	173	134	1759	53
4	4603	EL 31	24	3040	9.36	15.53	330	184	128	1215	50
18	4623	C515	25	2595	9.09	14.52	434	190	102	1570	37
General mean of all varieties				5169	17.16	15.09	453	212	138	1654	67
S. E. of mean (average)				449	1.35	0.40	50	38	19	131	6.75
Significant difference				1282	3.86	1.14	143	109	54	346	19
% coefficient of variation				10.64	9.65	3.24	13.5	22.14	17.1	9.25	12.41
Calc. F values (as rand. blks.)				16.36	15.19	16.56	10.16	6.64	25.68	11.07	6.00

Significant F 5% = 1.82 1% = 2.35

Table 4.--Variety Test 4, North Farm, Logan, Utah, 1965

7 varieties, 6 replications of each variety. Randomized blocks.

Code	Variety number	Description	ACRE YIELD Gross sugar	Tons beets	Percent sugar	Impurity index	PPM Amino N	Na	K	Beet count
1	4702S	0198 high-sugar selection	9041	27.33	16.54	449	233	86	1916	79
6	4711S	0198 low-sugar selection	8154	25.43	15.99	509	170	138	2374	74
7	4713S	0198 high-sugar selection	8050	25.98	15.48	483	205	137	1962	74
2	4703S	0198 low-sugar selection	8044	25.85	15.57	456	188	106	1940	59
3	4708S	0198 low-sugar selection	7918	25.92	15.25	475	188	101	1984	75
4	4709S	0198 low-sugar selection	7385	24.62	15.00	516	211	119	2070	83
5	4710S	0198 low-sugar selection	6320	19.58	16.10	483	249	104	1966	83
General mean of all varieties			7844	24.97	15.70	481	206	113	2030	75
S. E. of mean difference			307	0.83	0.32	38	24	15	98	5.80
Significant difference			626	1.69	0.65	77	49	31	200	11.83
% coefficient of variation			6.80	5.80	3.60	13.50	19.70	19.30	8.40	13.30
Calculated F values			14.60	18.13	5.25	0.88	2.70	3.50	5.30	3.90

Significant F 5% = 2.42 1% = 3.47

Table 5.--Variety Test 5, North Farm, Logan, Utah, 1965

81 varieties, 3 replications of each variety. Partly balanced lattice. Adjusted means.

Code	Variety number	Description	ACRE YIELD Gross sugar	Tons beets	Percent sugar	Impurity index	PPM Amino N	Na	K	Beet count
44	41241	SLC 138 X Ov. 3	9231	28.78	16.07	451	305	147	1473	89
33	41445	SLC 129 X 3611 (ud)	9036	26.44	17.10	427	247	118	1773	87
27	41271	AI-1 X CT 9B	9001	27.60	16.29	393	242	118	1429	84
30	41446	SLC 128 X 3611 (ud)	8824	25.26	17.48	307	155	94	1404	87
29	41390	NB-1 X Ov. 1	8512	27.00	15.74	384	212	124	1395	79
55	41274	CT 9mm X CT 9A	8481	27.39	15.46	395	194	111	1493	82
52	4133	NB-1 X SLC 129	8462	27.08	15.62	458	246	112	1714	82
39	41278	S3317 X CT 9A	8265	25.71	16.29	314	161	86	1265	75
21	41453	AI-1 X 3611 (ud)	8321	23.88	17.47	325	170	86	1466	82
20	41404	NB-1 X EL 32	8271	27.04	15.30	533	285	173	1901	75
14	41452	S3317 X 3611 (ud)	8221	24.25	16.95	405	278	103	1492	78
22	41391	CT 9mm X Ov. 1	8221	26.23	15.67	373	211	109	1340	82
8	4107	S3317 X C672	8156	26.08	15.63	491	283	86	1816	89
59	4176	NB-1 X FC 503	8081	26.85	14.99	548	336	129	1789	90
34	41365	FC 503 X CT 5B	8077	26.73	15.11	513	303	137	1677	82
40	41134	CT 9mm X Line 289	8064	24.41	16.57	445	349	98	1402	80
16	41173	FC 503 X CT 5B	8057	25.76	15.67	432	257	104	1524	84
24	41403	CT 9mm X EL 32	8053	26.85	15.00	522	203	208	2026	85
5	41166	CT 9mm X CT 5B	8039	25.62	15.69	348	150	107	1429	91
13	41447	AI-1 X 3611 (ud)	8037	23.58	16.96	405	397	85	1426	79
50	4131	308H01 X SLC 129	8032	28.17	14.25	575	222	186	2130	81
23	41395	FC 503 X Ov. 1	8029	25.75	15.59	490	375	121	1372	89
35	4165	NB-1 X EL 31	8028	25.58	15.68	485	297	153	1645	77
1	41275	NB-1 X CT 9A	8016	25.69	15.60	482	330	137	1494	78
78	4102	SLC 128 X C672	7978	25.28	15.75	420	243	84	1544	86
32	4151	AI-1 X EL 31	7968	25.62	15.55	541	341	161	1768	82
41	41334	308H01 X (CT5 X CT9)	7919	28.49	13.85	609	301	175	1930	82

Variety Test 5, Table 5 continued

Code	Var. No.	Description	ACRE YIELD Gross Sugar	Tons Beets	Percent Sugar	Impurity Index	PPM Amino N	Na	K	Beet Count
2	41358	SLC 128 X CT 5B	7867	25.26	15.52	395	205	106	1491	79
7	41342	308H01 X C515	7848	26.72	14.67	545	305	124	1782	85
26	41363	308H01 X CT 5B	7842	29.09	13.47	746	432	154	2074	88
74	41115	AI-10 X SLC 128	7837	25.11	15.60	400	224	90	1474	79
72	41152	NB-1 X CT 9	7796	26.55	14.78	516	264	150	1712	65
4	41360	CT 9 mm X CT 5B	7780	25.49	15.25	381	181	120	1431	79
17	41118	NB-1 X SLC 128	7671	25.19	15.25	426	215	128	1553	75
43	41168	SLC 128 X CT 5B	6752	24.23	15.80	367	210	101	1340	91
19	41393	S3317 X Ov. 1	7621	24.72	15.42	437	273	126	1424	85
70	41165	AI-10 X CT 5B	6703	22.88	16.63	318	182	69	1294	81
42	4105	CT 9 mm X C672	7583	24.05	15.76	443	204	96	1828	80
25	4132	CT 9 mm X SLC 129	7579	23.49	16.15	370	160	109	1598	87
15	4152	S3317 X EL 31	7569	24.51	15.48	517	396	121	1454	77
68	41364	S3317 X CT 5B	7531	24.53	15.36	439	281	113	1414	84
77	4115	SLC 129 X C507	7509	24.00	15.61	432	241	99	1597	89
71	4180	CT 9 mm X FC 503	7504	23.66	15.85	390	197	92	1554	81
63	41329	SLC 129 X (CT5 X CT9)	7485	23.57	15.85	378	196	86	1477	85
36	4120	308H01 X C507	7464	29.55	12.68	921	367	307	2711	84
56	41243	AI-10 X Ov. 3	7406	21.69	17.08	459	335	85	1666	81
64	41304	CT 9 mm X CT 9B	7352	23.25	15.86	404	258	90	1401	85
53	41436	FC503 X 00.5	7348	25.07	14.66	613	317	155	2087	91
9	41352	S3316 X C515	7238	22.69	15.89	382	219	85	1435	83
54	41335	S3317 X (CT 5 X CT 9)	7221	24.17	14.92	420	248	94	1377	87
58	4129	AI-1 X SLC 129	7210	24.03	14.96	422	199	124	1576	78
69	41149	AI-10 X CT 9	7203	21.91	16.51	434	282	81	1607	74
28	41167	NB-1 X CT 5B	7197	23.18	15.56	368	171	88	1470	83
31	4706C	SP561	7194	25.14	14.38	775	446	136	2410	81

Variety Test 5, Table 5 concluded

Code	Var. No.	Description	ACRE YIELD Gross Sugar	Tons Beets	Percent Sugar	Impurity Index	PPM Amino N	Na	K	Beet Count
48	4021	S3317 X C507	7171	23.13	15.49	392	170	117	1575	73
51	41130	SLC 129 X Line 289	7152	22.32	16.07	552	476	120	1480	76
3	41309	S3317 X CT 9B	7127	23.30	15.29	472	318	106	1446	88
6	41107	FC503 X SLC 128	7091	22.82	15.52	368	186	95	1402	81
66	41160	AI-1 X CT 9	6975	22.51	15.57	341	126	80	1473	72
80	4178	AI-1 X FC 503	6962	21.55	16.08	352	190	84	1414	85
18	41148	SLC 128 X CT 9B	6957	23.34	14.97	421	217	116	1451	81
73	41132	AI-1 X Line 289	6943	20.97	16.50	436	350	102	1343	82
37	41150	CT 9 mm X CT 9	6929	22.47	15.41	422	207	88	1659	77
67	41124	308H01 X Line 289	6893	21.16	16.30	471	392	85	1382	82
61	41351	FC 503 X C515	6875	21.74	15.83	446	253	130	1625	68
79	4182	308H01 X C502	6839	26.38	12.92	827	379	225	2353	89
60	4177	SLC 128 X FC 503	6816	21.79	15.65	382	200	93	1457	87
46	4173	SLC 129 X FC 503	6792	21.55	15.78	376	184	84	1514	75
12	41300	SLC 129 X CT 9B	6739	21.73	15.55	337	159	97	1313	89
10	4139	FC 503 X SLC 129	6679	19.86	16.92	353	188	79	1522	59
62	41301	SLC 128 X CT 9B	6645	21.81	15.16	358	185	109	1287	90
45	4183	S3317 X FC 503	6584	20.57	15.98	366	199	74	1434	69
76	4705C	SLC 3 O.P.	6550	21.16	15.42	530	251	177	1933	67
65	41345	SLC 129 X C515	6531	20.83	15.72	375	201	87	1429	66
57	41159	FC 503 X CT 9B	6410	20.37	15.74	334	147	72	1404	87
49	41344	NB-1 X C515	6408	19.85	16.09	478	324	129	1594	70
81	41113	SLC 128 X SLC 128	6385	20.91	15.15	333	168	90	1226	80
47	41131	AI-1 X (CT 5 X CT 9)	6261	20.70	15.13	351	152	86	1380	82
38	04174	AI-10 X FC 503	5549	16.92	16.38	332	164	60	1416	75
75	R4601	R201	3842	12.85	14.67	441	155	142	1758	64
11	4704C	AI-10 O.P.	2685	8.99	15.07	644	311	153	2399	24
General means of all varieties			7425	23.86	15.59	448	251	116	1593	81
S. E. of mean			213	0.65	0.22	34	28	28	72	3
Sig. diff.			596	1.81	0.62	96	80	79	202	8
% coefficient of variation			6.08	5.78	3.03	16.16	24.10	18.10	9.60	7.48
Calculated F values (rand. block)			9.1	10.80	8.20	5.90	3.60	7.70	7.60	6.40

Significant F 5% = 1.39 1% = 1.59

EVALUATION OF "QUALITY" IN SUGARBEETS

By Myron Stout

Various techniques have been used to ascertain the quality of sugarbeets during development of the industry. For a long time "apparent purity" or "true purity" was considered to be the best means of indicating the percentage of total sugar in the beet that could economically be extracted and recovered as granulated sugar. Processors, in general, have been more cognizant and alarmed at the progressive decline in recoverable sugar or "extraction" than breeders or agriculturists. However, the whole industry is well aware of this downward trend and are working together to define its causes and improve extraction. Processors have used thin-juice purity as the best indication of recoverable sugar because, beyond this step in processing, the impurities present cannot be removed by economic, conventional methods.

Several laboratory methods have been developed to simulate and evaluate thin-juice purity of beets in breeding, selection and agronomic studies to improve quality. Most of these methods are rather time consuming and require a considerable amount of sample material.

Carruthers et al. (1) have shown that the sum of the sodium and potassium salts added to the amino acids and betaine in the beets constitute 89% of the refractometric non-sugars in second carbonation or thin-juice. Carruthers has stated that since betaine does not present any chemical problems in processing, it is probable that summation of potassium sodium and amino nitrogen per 100 sugar represents the ultimate practical target in the tarehouse assessment of beet quality. In order to convert these values to probable molecular weights, he uses a factor of 10 for amino nitrogen, 2 1/2 for potassium and 3 1/2 for sodium.

Ellerton (2) and Haddock (3) have found that the determination of amino nitrogen by the Stanek-Pavlas method gives values that closely agree with those determined by the method of Moore and Stein, preferred by Carruthers. Haddock used the Stanek-Pavlas reagent as modified by Stout (4) in 1954. This modification was made to increase sensitivity of the method at high concentrations of amino nitrogen frequently encountered. Although breeding selections and most agronomic samples have routinely been analyzed at our laboratory for these three impurity constituents since 1952, no attempt to add their combined effects on quality was made until the impurity index idea was suggested by Carruthers. Use of such an index value is considered to be an important step forward in evaluating beets of superior processing quality regardless of the cause of the variation. If environmental and nutritional differences are held to a minimum, the probability of selection for genetic quality factors within a genetically variable population is enhanced. If these factors are ignored, the probability is very strong that the quality factors will be due to environment.

One large test reported by Carruthers indicated a nine-fold variation in purity due to location over that due to variety.

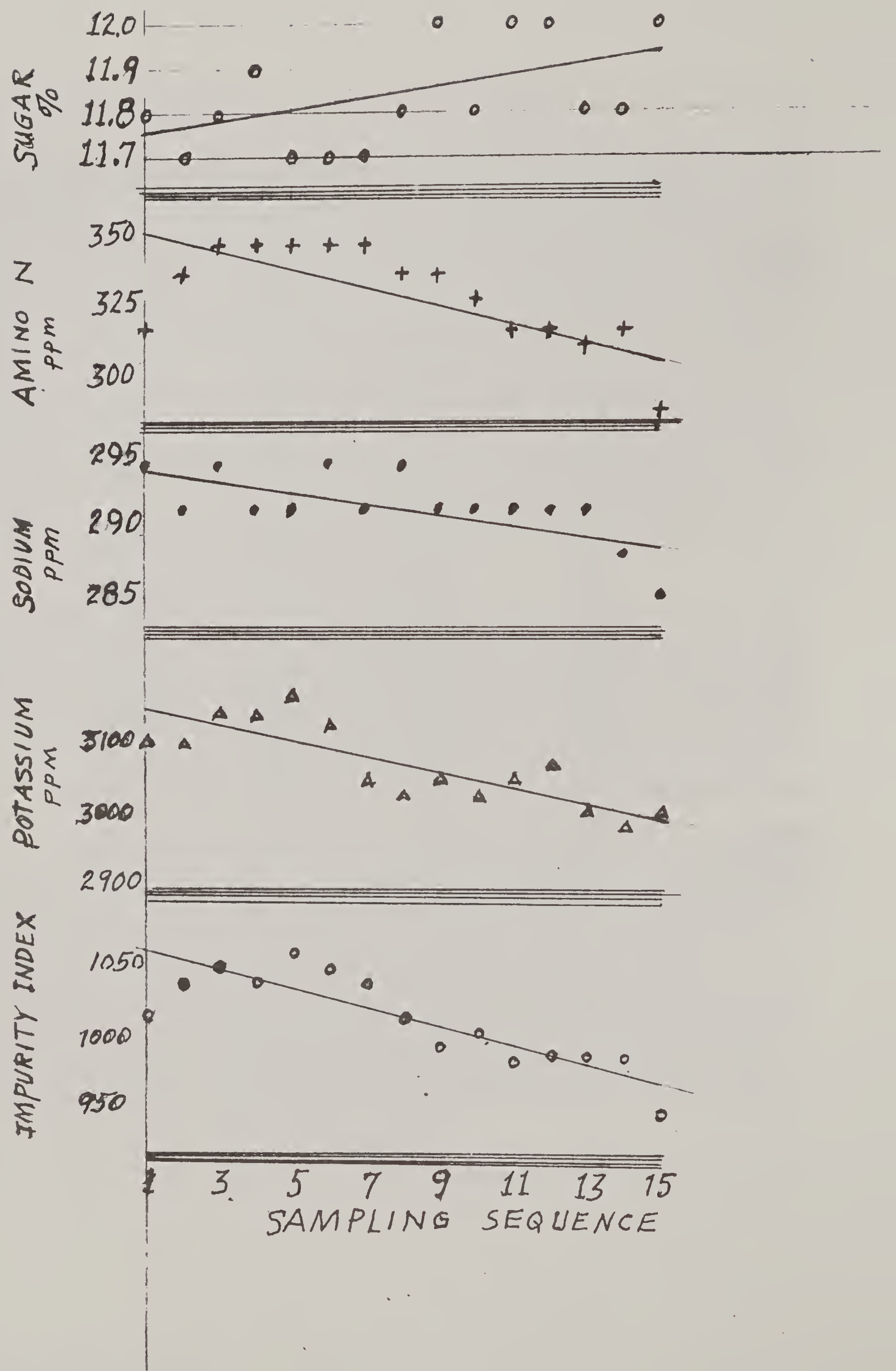
A small test was run to determine the relative precision of the analytical values to be expected in a routine laboratory operation. The excess pulp from several samples was combined and thoroughly mixed. Fifteen samples were weighed in a period of only 10 to 15 minutes and run in the usual manner. The data in Table 1 show a fairly high degree of precision in most of the values. However, there was an obvious decrease in potassium and impurity index of the later-weighed samples. When each value was plotted against sampling sequence, it was found that sugar increased and <u>all</u> of the impurity values decreased, possibly indicating a progressive change in samples due to liquid and pulp separation during the sampling period. Part of the progressive change in potassium values are probably analytical errors due to small changes in the instrument after being turned on. Standards were run after each six determinations. There was evidently a progressive change in the instrument at the start, but within the usual tolerance level for routine work. Sodium was run in reverse sequence at the end of the day with a completely warmed-up instrument.

Probably the best argument in favor of the impurity index value over that of purity is that the impurity index isolates more than 80% of the compounds that prevent crystallization from the sugar, while the purity value includes the sugar in both the numerator and denominator of the calculation. Small errors in readings of sugar, for example, may change the calculated value 20% of the range in purity between low- and high-quality beets. This is not true with impurity index values because the differences are very large and less affected by errors in sugar.

During the past season nine laboratory technicians, excluding sampling room personnel, ran as many as 515 samples for sugar and amino nitrogen in one day. Up to 1728 sodium or potassium determinations were subsequently run in a day by three people. All of these determinations were run on samples averaging about 20 grams of tissue. On extremely variable individual beet samples the amino N varied from 105 to 1553 ppm; sodium varied from 46 to 2375 ppm; potassium varied from 464 to 4167 ppm; and impurity index varied from 183 to 2393. Quality selections from such material can be easily made, but the probability that the differences are due to heredity seems extremely remote unless genetic variability is very large.

TABLE 1. Analytical values and standard deviation of fifteen consecutively weighed samples from the same lot of sugarbeet (sawed) pulp

Sample Number	Sugar %	Amino N PPM	Na PPM	K PPM	Impurity Index
1	11.8	316	294	3100	1013
2	11.7	335	291	3100	1037
3	11.8	345	294	3148	1048
4	11.9	345	291	3148	1037
5	11.7	345	291	3172	1058
6	11.7	345	294	3124	1047
7	11.7	345	291	3054	1034
8	11.8	335	294	3030	1012
9	12.0	335	291	3054	991
10	11.8	326	291	3030	1003
11	12.0	316	291	3054	983
12	12.0	316	291	3077	988
13	11.8	311	291	3007	987
14	11.8	316	288	2984	986
15	12.0	288	285	3007	948
Mean	11.83	238	291	3073	1011
Standard Deviation	0.119	17.0	2.4	57.6	31.3


SUGAR %
12.0
11.9
11.8
11.7
AMINO N ppm
350
325
300
SODIUM ppm
295
290
285
POTASSIUM PPM
3100
3000
2900
IMPURITY INDEX
1050
1000
950
1
3
5
7
9
11
13
15
SAMPLING SEQUENCE

The relative effect on purity and impurity index values due to a small error in sugar polarization may be illustrated by calculating both values on high and low quality sugarbeets. Assuming that calculated impurities are equal to 80% of the total impurities in thin juice:

	Sugar %	Parts per million: Amino N	Na	K	Calc. T.J. Purity %	Imp. Index No.
High quality	20.0	70	20	600	94.22	113
Low quality	12.0	800	800	3000	84.53	1525
Low quality + .2% error	12.2	800	800	3000	85.94	1500
Difference due to .2% error in sugar					1.41	25
Difference between high and low quality					9.69	1412
Calculation:	Error in % of difference				14.52	1.77

High quality:

700 Amino N X 10
70 Na X 3.5
1500 K X 2.5
2270 Total impurities

$$\frac{2270}{20} = \underline{113} \text{ Imp. Index}$$

2270 ppm + 20% = 2724 ppm or

$$\text{T.J. Purity} = \frac{20 \times 100}{20 + .2724} = \underline{94.22}$$

Low quality:

8000 Amino N X 10
2800 Na X 3.5
7500 K X 2.5
18300

$$\text{Imp. Index} = \frac{18300}{12} = \underline{1525}$$

$$\text{Imp. Index} = \frac{18300}{12.2} = \underline{1500}$$

18300 = 20% = 21960 ppm or

$$\text{T.J. Purity} = \frac{120 \times 100}{12.0 + 2.196} = \underline{84.53}$$

$$\text{T.J. Purity} = \frac{12.2 \times 100}{14.196} = \underline{85.94}$$

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PART VIII

DEVELOPMENT AND EVALUATION
of
SUGARBEET BREEDING MATERIAL AND VARIETIES CARRYING RESISTANCE TO LEAF SPOT AND CURLY TOP

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  Agricultural Experiment Station
Panhandle Experiment Station, Oklahoma
  Agricultural Experiment Station

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DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING MATERIAL AND VARIETIES CARRYING RESISTANCE TO LEAF SPOT AND CURLY TOP, 1965 1/, 2/

John O. Gaskill, Charles L. Schneider,
Albert M. Murphy, and Gerald E. Coe

The program of development and evaluation of sugarbeet breeding material and varieties carrying resistance to both leaf spot (*Cercospora beticola*) and curly top (virus) was continued at Fort Collins in 1965 in about the same way as in the preceding year (3) 3/ with some modifications and expansion. Very substantial contributions were made by other U. S. Department of Agriculture stations in the evaluation of breeding lines and experimental hybrids for resistance to diseases, especially curly top. Such stations, state experiment stations, and several sugar companies cooperated in the agronomic evaluation of a set of varieties having some degree of resistance to both leaf spot and curly top (so-called "LSR-CTR" varieties) and other material at a number of locations in various states. This report pertains to the results of these undertakings in terms of performance data. Details regarding the breeding work, preliminary observational evaluation of breeding lines, etc., have ben largely omitted.

1/ This progress report pertains to breeding and evaluation work conducted at Fort Collins, Colorado, and to cooperative tests conducted elsewhere by various investigators, with results compiled at the Fort Collins station. The work at Fort Collins was performed by the Crops Research Division, A.R.S., U.S. Department of Agriculture, in cooperation with the Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation, and was supported in part by funds contributed by the National Sugar Manufacturing Company. Assistance rendered by Joseph A. Elder and Luther W. Lawson, Agricultural Research Technicians, Crops Research Division, in conducting breeding, evaluation, and other work at Fort Collins is acknowledged. Participation by other investigators in the research program covered by this report is acknowledged in the tables and accompanying discussion.

2/ A phase of Beet Sugar Development Foundation Project 25.

3/ Single-digit numbers in parentheses refer to Literature Cited.

High Lights of Accomplishments

1. Extensive evaluation tests at various locations in 1965 clearly established the value of the monogerm, male-sterile F_1, FC (502/2 x 504)MS, for use as the female in hybridizations with pollinators having combined resistance to leaf spot and black root (e.g. SP 5822-0 and SP 59B18-0) and with pollinators resistant to leaf spot and curly top (e.g. FC 901). FC (502/2 x 504)MS has high resistance to leaf spot, and sucrose percentage is satisfactory. It is susceptible to curly top and presumably also to black root.

2. The multigerm, LSR-CTR variety, FC 901, was shown to have considerable promise for use as a pollinator in the production of LSR-CTR, monogerm hybrids. It is high in curly top resistance, moderate in leaf spot resistance, and has satisfactory sucrose percentage. FC 901 was developed by backcrossing, using US 201 as the source of leaf spot resistance--i.e. as the non-recurring parent. FC 901 is not a finished product. It is segregating for leaf spot resistance and presumably also for curly top resistance and combining ability. It is considered an excellent source from which superior lines may be selected for use as pollinators.

3. The monogerm hybrid, FC (502/2 x 504)MS x FC 901, was found to have curly top resistance about equal to that of the variety used as the standard in 1965 evaluation tests, [SL (129 x 133)MS x SP 5822-0]. It is superior to the standard variety in leaf spot resistance. In a series of cooperative agronomic tests involving 13 locations in 9 states, the average gross sucrose yield and sucrose percentage for FC (502/2 x 504)MS x FC 901, expressed as percent of the corresponding averages for the standard variety, were 108.4 and 102.5, respectively. Corresponding percent-of-standard figures for the local check variety at the 13 locations were 103.2 and 100.1. Under severe leaf spot exposure at Fort Collins, FC (502/2 x 504)MS x FC 901 significantly exceeded the local check (GW 674-56C) in root yield, sucrose percentage, and gross sucrose yield. Its superiority in gross sucrose yield amounted to 8.9% and was highly significant.

4. Two LSR-CTR, monogerm, type-0 or near type-0, inbred lines were found to have relatively high curly top resistance, medium to high leaf spot resistance, and apparently acceptable sucrose percentage and combining ability. One of these lines, FC 601, has high leaf spot resistance--about equal to that of US 201. The other, SP 632028s1, has medium leaf spot resistance--about equal to that of SP 5481-0.

5. Observational tests for leaf spot and curly top resistance at Fort Collins, Colorado, and Logan, Utah, respectively, indicated that several new, type-0 or near type-0, monogerm, inbred lines combine high levels of resistance to both diseases.

Top-cross Tests at Fort Collins Involving Leaf Spot Resistant, Monogerm, Type-0, Inbred Lines

Since leaf spot resistant, monogerm, type-0, inbred lines may have potential value for the production of LSR-CTR hybrids, results of combining ability tests for such lines have a rightful place in this report, even though the lines themselves may lack curly top resistance. Two combining ability tests of the top-cross type were conducted at Fort Collins in 1965 under severe, artificially intensified, leaf spot exposure. One of these tests (Experiment no. 2A) involved hybrids having varieties resistant to leaf spot (Cercospora beticola) and black root (Aphanomyces cochlioides)--so-called "LSR-BRR" varieties--as male parents. The hybrids in the other test (Experiment 3A), had resulted from pollination by LSR-CTR varieties or lines. Randomized block experimental designs were used with 1-row, 20-foot plots, and 8 replications. Rows were 20 inches apart. At harvest, all roots in a 17-foot section in each plot were washed, weighed, and analyzed for sucrose percentage. Stands and field uniformity were good, and both tests are considered reliable. The top-cross hybrids in Experiment 3A were evaluated for curly top resistance by A. M. Murphy, U. S. Department of Agriculture, in field plots at Thatcher, Utah. The parental material involved in Experiments 2A and 3A is described in Table 1.

Results, Experiment 2A:

The results of Experiment 2A are presented in Tables 2, 3, 4, and 5. In this test, as in the preceding year (3), single-cross hybrids involving FC 502/2 and FC 503 as females and LSR-BRR multigerm material as pollinators were relatively high in both sucrose percentage and yield of gross sucrose. The favorable performance of FC 504 in the single-crosses in Experiment 2A (1965) was in keeping with results reported for that line (as SP 592013sl) in 1963 (2). Results shown for SP 602000sl in Experiment 2A are quite promising and indicate the desirability of further work with that line.

The results for the 3-way hybrids (Tables 2-5) provide an opportunity for comparisons of LSR-BRR pollinators--comparisons that may be of interest particularly in eastern sugarbeet areas where black root of the Aphanomyces type is an economic problem. It is quite clear that the monogerm variety, SP 621160-00 was inferior to the other pollinators under the conditions of Experiment 2A. Each of the other two pollinators--both multigerm--produced sets of hybrids that were substantially above the standard variety, SL (129 x 133)MS x SP 5822-0 in productivity and sucrose percentage. These two sets of hybrids were about alike in all attributes presented in the table except leaf spot resistance. The set having SP 5822-0 as the male parent was significantly superior in leaf spot resistance. But in spite of this advantage, the set having SP 59B18-0 as the male parent averaged somewhat higher in gross sucrose yield.

Among the 3-way hybrids in Experiment 2A (Tables 2-5), two are of special interest because of extensive evaluation and favorable performance of the F_1 female parent (temporary code a x d) in other tests in 1965. These two hybrids are FC (502/2 x 504) MS x SP 5822-0 and FC (502/2 x 504) MS x SP 59B18-0. Each of these hybrids was significantly superior to the standard variety in leaf spot resistance, root yield, sucrose percentage, and gross sucrose yield. The average gross sucrose production for the two hybrids was 4,598 pounds per acre, 16.9 percent above that of the standard variety, a highly significant difference. Results from a top-cross test of East Lansing, Michigan, hybrids (Fort Collins Experiment 4A), not included in this report, afford another opportunity for comparison of FC (502/2 x 504) x SP 59B18-0 with the standard variety. In that test, the former surpassed the latter by highly significant amounts in leaf spot resistance, root yield, sucrose percentage, and gross sucrose yield. Its superiority in gross sucrose yield amounted to 19.5%.

Results, Experiment 3A:

Results obtained from the agronomic-test portion of Experiment 3A at Fort Collins are presented in Tables 6, 7, 8, and 9. The curly top resistance data, obtained at Thatcher, Utah, are shown in Table 10. Using the results for the 3-way hybrids for comparisons of pollinators, it appears that the diploid variety, FC 901, is superior to the two tetraploids in the level of sucrose percentage imparted to the hybrids. Root-yield differences, between the two sets of hybrids, also were in favor of the FC 901 hybrids, though non-significant. Differences between the two sets of hybrids in resistance to leaf spot and curly top were slight.

Four of the FC 901 hybrids exceeded the standard variety, SL (129 x 133) MS x SP 5822-0, by approximately significant amounts, at least, in both sucrose percentage and gross sucrose yield. Females involved in those hybrids included FC 502/2, FC 503, FC 504, and SP 581194s1. Each of the four hybrids was at least equal to SL (129 x 133) MS x SP 5822-0 in leaf spot resistance and exhibited some degree of curly top resistance. One of those hybrids, FC (502/2 x 504) MS x FC 901 is of special interest because of its outstanding performance in the 1965 Cooperative Tests of LSR-CTR Varieties.

Table 1 .--Description of parental material involved in top-cross tests, Fort Collins, Colo., 1965 (Exp. no. 2A and 3A).

Source	Immed. parent or other no.	Strain no.	No. gen. self.	Description
I. Monogerm, type-0, LSR, inbred lines (2n):				
US 201 MM X V.F.S. 715 mm	FC 502	FC 502/2	2	
V.F.S. 716	SP 561403sl	FC 503	2 or +	
V.F.S. 6-2	SP 592013sl	FC 504	2 or +	
US 201 MM X misc. mm; SP 581219sl	SP 602063sl	FC 505	2	
US 201 MM X misc. mm		SP 581181sl	1	
do.		SP 581194sl	1	
do.		SP 581222sl	1	
V.F.S. S-27		SP 602000sl	2 or +	
US 201 MM X misc. mm	SP 581219sl	SP 602009sl	2	
do.	SP 581179sl	SP 602039sl	2	
do.	SP 581180sl	SP 602082sl	2	
do.	SP 581194sl	SP 602105sl	2	
do.	SP 581179sl	SP 602116sl	2	
do.	SP 581181sl	SP 602122sl	2	
do.	SP 582095.	SP 602154sl	2	
II. Pollinators:				
Misc. CTR lines + US 201		FC 901		LSR-CTR, multigerm, 2n
V. F. and H. Savitsky		S-62-16		" " , " , 4n
do.		S-63 pool		" " , " , "
Beltsville, Md. (G. E. Coe)		SP 5822-0		LSR-BRR, " , 2n
E. Lansing, Mich. (Hogaboam)		SP 59B18-0		" " , " , "
Misc. lines		SP 621160-00		" " , monogerm, "

Table 2 .--Results of top-cross test, LSR-BRR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. No. 2A; basic data presented as 8-plot averages.

Gross Sucrose per Acre (Lbs.)

♀ CMS phase of mm, LSR, T.O. lines below; 2n			♂ LSR-BRR lines; 2n					
			MM		mm	Aver. col. 4 & 5	Aver. col. 4, 5 & 6	LSD (.05) for av. of avs.
Strain no.	Equiv. stage	Temp. code	SP 5822-0	SP 59B18-0	SP 621160-00			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			I. Three-way hybrids					
See below		a x b	4473	4822	4116	4648	4470	
" "		a x c	4655	4733	3950	4694	4446	
" "		a x d	4598	4597	4036	4598	4410	
" "		c x d	4644	4685	3953	4665	4427	
Average			4593	4709	4014			192
			II. Single crosses					
FC 502/2	B_3	a	4285	4571		4428		
FC 503	B_{3-4}	b	4514	4635		4575		
SP 602039sl[a/]	B_2		3946	3651		3799		
SP 602116sl[a/]	B_2		3367					
SP 602082sl	B_2			3622				
SP 581181sl	B_1			4191				
SP 602122sl[a/]	B_2		3834	3981		3908		
SP 581194sl	B_3	c	4103	4170		4137		
SP 602105sl	B_2		4173	4353		4263		
SP 602009sl[a/]	B_2		4210	4006		4108		
FC 505	B_2		3884	4228		4056		
SP 581222sl	B_2			4205				
SP 602154sl	B_1		4081	4045		4063		
FC 504	B_2	d	4841	4786		4814		
SP 602000sl	B_1		4810	4696		4753		
			III. Parental and check material					
Acc. 2623 (SP 5822-0)				3853				
Acc. 2684 [SL (129 X 133) MS X SP 5822-0]				3932				
LSD (.05) for 8-plot avs.			382	382	382			
LSD (.05) for av. of averages						272	222	

[a/] The CMS phase of the indicated line is segregating for M and m.

Table 3 .--Results of top-cross test, LSR-BRR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. No. 2A; basic data presented as 8-plot averages.

Roots per Acre (Tons)

♀ CMS phase of mm, LSR, T.O. lines below; 2n: Strain no.	Equiv. stage	Temp. code	♂ LSR-BRR lines; 2n: MM: SP 5822-0	MM: SP 59B18-0	mm: SP 621160-00	Aver. col. 4 & 5	Aver. col. 4, 5 & 6	LSD (.05) for av. of avs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I. Three-way hybrids								
See below		a x b	13.59	14.65	12.48	14.12	13.57	
" "		a x c	13.87	14.24	11.70	14.06	13.27	
" "		a x d	14.13	14.28	12.22	14.21	13.54	
" "		c x d	14.05	14.34	12.37	14.20	13.59	
Average			13.91	14.38	12.19			0.57
II. Single crosses								
FC 502/2	B_3	a	12.81	13.30		13.06		
FC 503	B_{3-4}	b	13.93	14.21		14.07		
SP 602039sl[a]	B_2		12.36	11.58		11.97		
SP 602116sl[a]	B_2		10.82					
SP 602082sl	B_2			11.51				
SP 581181sl	B_1			12.72				
SP 602122sl[a]	B_2		11.83	12.41		12.12		
SP 581194sl	B_3	c	12.02	12.66		12.34		
SP 602105sl	B_2		13.04	13.18		13.11		
SP 602009sl[a]	B_2		12.85	12.39		12.62		
FC 505	B_2		12.17	13.25		12.71		
SP 581222sl	B_2			12.91				
SP 602154sl	B_1		12.61	12.47		12.54		
FC 504	B_2	d	15.52	15.12		15.32		
SP 602000sl	B_1		14.55	13.99		14.27		
III. Parental and check material								
Acc. 2623 (SP 5822-0)					12.42			
Acc. 2634 [SL (129 X 133) MS X SP 5822-0]					12.51			
LSD (.05) for 8-plot avs.			1.13	1.13	1.13			
LSD (.05) for av. of avs.						0.80	0.65	

[a] The CMS phase of the indicated line is segregating for M and m.

Table 4 .--Results of top-cross test, LSR-BRR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. No. 2A; basic data presented as 8-plot averages.

Sucrose Percentage

♀ CMS phase of mm, LSR, T.O. lines below; $2\underline{n}$			♂ LSR-BRR lines; $2\underline{n}$			Aver. col. 4 & 5	Aver. col. 4, 5 & 6	LSD (.05) for av. of avs.
			MM		mm			
Strain no.	Equiv. stage	Temp. code	SP 5822-0	SP 59B18-0	SP 621160-00			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			I. Three-way hybrids					
See below		a x b	16.45	16.46	16.49	16.46	16.47	
" "		a x c	16.74	16.61	16.87	16.68	16.74	
" "		a x d	16.27	16.11	16.51	16.19	16.30	
" "		c x d	16.53	16.32	15.97	16.43	16.27	
Average			16.50	16.38	16.46			0.17
			II. Single crosses					
FC 502/2	B_3	a	16.72	17.17		16.95		
FC 503	B_{3-4}	b	16.20	16.27		16.24		
SP 602039sl[a/]	B_2		15.95	15.75		15.85		
SP 602116sl[a/]	B_2		15.56					
SP 602082sl	B_2			15.74				
SP 581181sl	B_1			16.44				
SP 602122sl[a/]	B_2		16.19	16.02		16.11		
SP 581194sl	B_3	c	17.04	16.46		16.75		
SP 602105sl	B_2		15.99	16.51		16.25		
SP 60200[illegible]sl[a/]	B_2		16.37	16.16		16.27		
FC 505	B_2		15.96	15.94		15.95		
SP 581222sl	B_2			16.27				
SP 602154sl	B_1		16.18	16.17		16.18		
FC 504	B_2	d	15.60	15.83		15.72		
SP 602000sl	B_1		16.54	16.79		16.67		
			III. Parental and check material					
Acc. 2623 (SP 5822-0)				15.52				
Acc. 2634 [SL (129 X 133) MS X SP 5822-0]				15.66				
LSD (.05) for 8-plot avs.			0.34	0.34	0.34			
LSD (.05) for av. of avs.						0.24	0.20	

a/ The CMS phase of the indicated line is segregating for M and m.

Table 5 .--Results of top-cross test, LSR-BRR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. No. 2A; basic data presented as 8-plot averages.

Leaf Spot Grades[a/]

♀ CMS phase of mm, LSR, T.O. lines below; 2n			♂ LSR-BRR lines; 2n			Aver. col. 4 & 5	Aver. col. 4, 5, & 6	LSD (.05) for av. of avs.
			MM		mm			
Strain no.	Equiv. stage	Temp. code	SP 5822-0	SP 59B18-0	SP 621160-00			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I. Three-way hybrids								
See below		a x b	1.4	2.3	2.0	1.9	1.9	
" "		a x c	1.4	2.5	2.6	2.0	2.2	
" "		a x d	1.1	1.8	2.3	1.5	1.7	
" "		c x d	1.4	2.8	2.7	2.1	2.3	
Average			1.3	2.4	2.4			0.3
II. Single crosses								
FC 502/2	B_3	a	0.8	1.4		1.1		
FC 503	B_{3-4}	b	2.3	2.7		2.5		
SP 602039sl[b/]	B_2		3.1	3.6		3.4		
SP 602116sl[b/]	B_2		2.8					
SP 602082sl	B_2			3.0				
SP 581181sl	B_1			3.1				
SP 602122sl[b/]	B_2		2.2	3.0		2.6		
SP 581194sl	B_3	c	1.3	3.1		2.2		
SP 602105sl	B_2		2.8	3.3		3.1		
SP 602009sl[b/]	B_2		2.8	3.6		3.2		
FC 505	B_2		2.7	2.6		2.7		
SP 581222sl	B_2			2.7				
SP 602154sl	B_1		2.4	1.9		2.2		
FC 504	B_2	d	1.3	2.3		1.8		
SP 602000sl	B_1		0.5	1.5		1.0		
III. Parental and check material								
Acc. 2623 (SP 5822-0)				2.2				
Acc. 2634 [SL (129 X 133) MS X SP 5822-0]				3.6				
LSD (.05) for 8-plot avs.			0.6	0.6	0.6			
LSD (.05) for av. of avs.						0.4	0.3	

a/ Leaf spot grades (by J. A. Elder, 9/2/65): 0 = no leaf spot; 10 = complete defoliation.

b/ The CMS phase of the indicated line is segregating for M and m.

Table 6 .--Results of top-cross test, LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. no. 3A; basic data presented as 8-plot averages.

Gross Sucrose per Acre (Lbs.)

♀ CMS phase of mm, LSR, T.O. lines below; 2n: Strain no.	Equiv. stage	Temp. code[a]	♂ LSR-CTR, multigerm lines: 2n: FC 901	4n: S-62-16	4n: S-63 pool	Aver. col. 4 & 5	Aver. col. 4, 5, & 6	LSD (.05) for av. of avs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
I. Three-way hybrids								
See below		a x b	4520	4059	3974	4290	4184	
" "		a x c	3770	3938	4128	3854	3945	
" "		a x d	4270	4063	3938[c]	4167	4090	
" "		c x d	4293	4071		4182		
Aver., a x b, a x c, & a x d			4187	4020	4013			188
Aver., all the above hybrids			4213	4033				163
II. Single crosses								
FC 502/2	B_3	a	3799					
FC 503	B_4	b	4540					
SP 602039sl[b]	B_2		3540					
SP 602009sl[b]	B_2		3746					
FC 504	B_2	d	4233					
III. Parental, check, and misc. material								
SP 641204HO (FC 901)					2707			
SP 641205HO (S-62-16)					3273			
SP 641206HOO (S-63 pool)					3489[c]			
Acc. 2620 (Amal. S32DR10)					2917			
Acc. 2621 (Holly NBHH1)					3952			
Acc. 2622 (Holly HH9)					4069[c]			
Acc. 2623 (SP 5822-0)					3760			
Acc. 2634 [SL (129 X 133) MS X SP 5822-0]					3946			
LSD (.05) for 8-plot avs.			325	325	325			
LSD (.05) for av. of averages						230	188	

a/ Strain no. for temporary code "c" is SP 581194sl.

b/ The CMS phase of the indicated line is segregating for M and m.

c/ One missing-plot value was estimated.

Table 7 .--Results of top-cross test, LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. no. 3A; basic data presented as 8-plot averages.

Roots per Acre (Tons)

♀ CMS phase of mm, LSR, T.O. lines below; 2n			♂ LSR-CTR, multigerm lines			Aver. col. 4 & 5	Aver. col. 4, 5, & 6	LSD (.05) for av. of avs.
			2n	4n				
Strain no.	Equiv. stage	Temp. code[a]	FC 901	S-62-16	S-63 pool			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
I. Three-way hybrids								
See below		a x b	14.38	13.28	13.19	13.83	13.62	
" "		a x c	11.96	12.75	13.23	12.36	12.65	
" "		a x d	13.95	13.54	12.92[c]	13.75	13.47	
" "		c x d	13.75	13.43		13.59		
Aver., a x b, a x c, & a x d			13.43	13.19	13.11			0.62
Aver., all the above hybrids			13.51	13.25				0.53
II. Single crosses								
FC 502/2	B_3	a	12.00					
FC 503	B_4	b	14.75					
SP 602039sl[b]	B_2		11.88					
SP 602009sl[b]	B_2		11.82					
FC 504	B_2	d	13.88					
III. Parental, check, and misc. material								
SP 641204HO (FC 901)					9.49			
SP 641205HO (S-62-16)					10.85			
SP 641206HOO (S-63 pool)					11.77[c]			
Acc. 2620 (Amal. S32DR10)					9.97			
Acc. 2621 (Holly NBHH1)					13.68			
Acc. 2622 (Holly HH9)					14.19[c]			
Acc. 2623 (SP 5822-0)					12.82			
Acc. 2634 [SL (129 X 133) MS X SP 5822-0]					13.39			
LSD (.05) for 8-plot avs.			1.07	1.07	1.07			
LSD (.05) for av. of averages						0.76	0.62	

a/ Strain no. for temporary code "c" is SP 581194sl.

b/ The CMS phase of the indicated line is segregating for M and m.

c/ One missing-plot value was estimated.

Table 8 .--Results of top-cross test, LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. no. 3A; basic data presented as 8-plot averages.

Sucrose Percentage

♀ CMS phase of mm, LSR, T.O. lines below; 2n			♂ LSR-CTR, multigerm lines			Aver. col. 4 & 5	Aver. col. 4, 5, & 6	LSD (.05) for av. of avs.
Strain no.	Equiv. stage	Temp. code[a/]	2n FC 901	4n S-62-16	4n S-63 pool			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
I. Three-way hybrids								
See below		a x b	15.72	15.27	15.08	15.50	15.36	
" "		a x c	15.76	15.44	15.60	15.60	15.60	
" "		a x d	15.31	15.00	15.26	15.16	15.19	
" "		c x d	15.61	15.15		15.38		
Aver., a x b, a x c, & a x d			15.60	15.24	15.31			0.20
Aver., all the above hybrids			15.60	15.22				0.17
II. Single crosses								
FC 502/2	B_3	a	15.84					
FC 503	B_4	b	15.38					
SP 602039sl[b/]	B_2		14.91					
SP 602009sl[b/]	B_2		15.86					
FC 504	B_2	d	15.26					
III. Parental, check, and misc. material								
SP 641204HO (FC 901)					14.27			
SP 641205HO (S-62-16)					15.09			
SP 641206HOO (S-63 pool)					14.82			
Acc. 2620 (Amal. S32DR10)					14.62			
Acc. 2621 (Holly NBHH1)					14.47			
Acc. 2622 (Holly HH9)					14.33			
Acc. 2623 (SP 5822-0)					14.66			
Acc. 2634 [SL (129 X 133) MS X SP 5822-0]					14.75			
LSD (.05) for 8-plot avs.			0.35	0.35	0.35			
LSD (.05) for av. of avs.						0.25	0.20	

a/ Strain no. for temporary code "c" is SP 581194sl.

b/ The CMS phase of the indicated line is segregating for M and [illegible].

Table 9 .--Results of top-cross test, LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1965; Exp. no. 3A; basic data presented as 8-plot averages.

Leaf Spot Grades[a/]

♀ CMS phase of mm, LSR, T.O. lines below; 2n: Strain no.	Equiv. Stage	Temp. code[b/]	♂ LSR-CTR, multigerm lines: 2n: FC 901	4n: S-62-16	4n: S-63 pool	Aver. col. 4 & 5	Aver. col. 4, 5, & 6	LSD (.05) for av. of avs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
I. Three-way hybrids								
See below		a x b	2.8	3.3	3.1	3.1	3.1	
" "		a x c	3.0	2.9	3.2	3.0	3.0	
" "		a x d	2.6	2.9	3.2	2.8	2.9	
" "		c x d	2.9	2.8		2.9		
Av., a x b, a x c, & a x d			2.8	3.0	3.2			0.3
Av., all the above hybrids			2.8	3.0				0.3
II. Single crosses								
FC 502/2	B_3	a	3.0					
FC 503	B_4	b	3.4					
SP 602039sl[c/]	B_2		3.3					
SP 602009sl[c/]	B_2		3.3					
FC 504	B_2	d	2.4					
III. Parental, check and misc. material								
SP 641204HO (FC 901)					4.6			
SP 641205HO (S-62-16)					3.6			
SP 641206HOO (S-63 pool)					3.1			
Acc. 2620 (Amal. S32DR10)					6.5			
Acc. 2621 (Holly NBHH1)					4.3			
Acc. 2622 (Holly HH9)					5.8			
Acc. 2623 (SP 5822-0)					1.7			
Acc. 2634 [SL (129 X 133) MS X SP 5822-0]					3.7			
LSD (.05) for 8-plot averages			0.6	0.6	0.6			
LSD (.05) for av. of averages						0.4	0.3	

a/ Leaf spot grades (by J. A. Elder, 9/2/65): 0 = no leaf spot; 10 = complete defoliation.

b/ Strain no. for temporary code "c" is SP 581194sl.

c/ The CMS phase of the indicated line is segregating for M and m.

Table 10 .--Curly top resistance comparisons, LSR-CTR, monogerm hybrids[a/], Thatcher, Utah, 1965, by A. M. Murphy; basic results, as presented, were obtained from a minimum of 2 rows, 50 ft. long.

♀ CMS phase of mm, LSR, T.O. lines below; 2n: Strain no.[c/]	Equiv. stage	Temp. code	Percent curly top (Sept. 15) ♂ LSR-CTR, multigerm lines 2n: FC 901	4n: S-62-16	4n: S-63 pool	Aver. col. 4 & 5	Aver. col. 4, 5 and 6	Curly top grade (Oct. 1)[b/] ♂ LSR-CTR, multigerm lines 2n: FC 901	4n: S-62-16	4n: S-63 pool	Aver. col. 9 & 10	Aver. col. 9, 10 and 11
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
I. Three-way hybrids												
See below		a x b	73.7	76.5	66.7	75.1	72.3	4.0	4.0	4.0	4.0	4.0
" "		a x c	79.8	57.3	67.0	68.6	68.0	4.0	4.0	4.0	4.0	4.0
" "		a x d	74.2	59.0	54.9	66.6	62.7	4.0	4.0	4.0	4.0	4.0
" "		c x d	87.2	73.3		80.3		4.5	4.0		4.3	
Aver., a x b, a x c, and a x d			75.9	64.3	62.9			4.0	4.0	4.0		
Aver., all the above hybrids			78.7	66.5				4.1	4.0			
II. Single crosses												
FC 502/2	B_3	a	71.4					4.0				
FC 503	B_4	b	87.7					5.0				
SP 602039sl[d/]	B_2		83.5					4.5				
SP 602009sl[d/]	B_2		91.8					5.0				
FC 504	B_2	d	73.2					4.0				
III. Parental and check material												
SP 641204HO (FC 901)				58.0					4.0			
SP 641205HO (S-62-16)				41.2					3.0			
SP 641206HOO (S-63 pool)				53.4					4.0			
Acc. 2483 (SP 5481-0)				84.0					5.5			
SP 631210HO (SP 6051-0)				62.8					4.0			
US 33				84.1					4.8			
US 41				45.4					3.3			

a/ Same hybrids as in Exp. 3A, Ft. Collins, Colo., 1965.

b/ Basis of curly top grades: 0 = healthy; 9 = death due to curly top.

c/ Strain no. for temporary code "c" is SP 581194sl.

d/ The CMS phase of the indicated line is segregating for M and m.

Cooperators' Tests of Top-cross Hybrids

Some of the hybrids evaluated in Experiments 2A and 3A at Fort Collins also were evaluated in agronomic tests by cooperators at several locations as follows:

	Location	Cooperating agency and personnel
1-a	Rocky Ford, Colo.	Amer.Crystal Sug.Co.; R. E. Finkner & staff
1-b	" " "	" " " " " " " "
2	Johnson, Kan.	" " " " " " " "
3	Garden City, Kan.	" " " " " " " "
4	Mason City, Ia.	" " " " " " " "
5	Hereford, Tex.	Holly Sug. Corp.; D.F.Peterson, Paul Scott
6	Weslaco, Tex.	Tex. Agr. Exp. Sta.; W.R.Cowley & staff
7	Progreso, Tex.	" " " " " " " "

The tests at Weslaco and Progreso were planted in the fall of 1964 and harvested in the following spring. All other tests were spring planted and fall harvested in 1965. Bolting was not a problem in the Weslaco and Progreso tests in spite of the fact that most of the material in those tests was not bolting resistant.

The results of these tests, expressed as percent of the performance of the standard variety, SL (129 x 133) MS x SP 5822-0, are presented in Tables 11, 12, and 13. The number of replications and the estimated level of disease exposure in each test are shown in the tables. An indication of the degree of precision in the respective tests is given in the form of LSD values expressed as percent of the actual average yield or sucrose percentage of the standard variety. Ordinarily, one or two local check varieties were included in each test by the cooperator, and results for those varieties are included in the tables. At Weslaco and Progreso, Texas, there were many varieties or hybrids in addition to those shown in the tables. The choice of SP 5822-0 and US H6 as so-called "local checks" in presenting the results for the Weslaco and Progreso locations was an arbitrary one, based on the fact that those two varieties were widely used in another series of cooperative tests in 1965.

In the cooperators' tests, as in Experiment 2A, LSR-BRR hybrids having SP 621160-00 as the male parent were consistently lower in gross sucrose yield than comparable hybrids having SP 5822-0 or SP 59B18-0 as the male parent. Among the latter hybrids, FC (502/2 x 504) MS x SP 59B18-0 is of special interest. In locations 1-a, 4, 6, and 7, its gross sucrose yield, expressed as percent of that of the standard variety, was 99, 118, 127, and 111, respectively (average 113.8). Sucrose percentage of that hybrid at the respective locations, expressed in the same way, was 103, 103, 96, and 103 (average 101.3).

The results of the excellent test at Hereford, Texas, afford an opportunity to appraise performance under dual exposure to leaf spot and curly top--both severe. Three of the experimental hybrids significantly exceeded the better of the two local checks (HH 10) in gross sucrose yield. Each of those hybrids had FC 504 as a component. The outstanding hybrid, a triploid [FC (502/2 x 504) MS x S-62-16], produced 111 and 99 percent of the standard variety in gross sucrose yield and sucrose percentage, respectively.

Table 11 .--Summary of harvest results of cooperators' agronomic evaluation tests of experimental hybrids, 1965; as percent of the standard variety, SL (129 X 133) MS X SP 5822-0.

Gross Sucrose Yield

Description	Seed no.	Location: 1-a R.F. Colo.	1-b R.F. Colo.	2 John. Kan.	3 G.C. Kan.	4 M.C. Ia.	5 Herf. Tex.	6 Wes. Tex.	7 Prog. Tex. 4/12	Av. 1-a & 4	Av.[a] 1-b, 2, 3 & 5	Av. 6 & 7
Disease exposure[b]		LS-1 Rh-1	LS-1 Rh-1			LS-1 Rh-1	LS-3 CT-3	LS-2	LS-1			
No. of replications		9	12	3	3	9	9	4	4			
(FC 502/2 X FC 503) MS X SP 5822-0	SP 641201H01	91				109				100		
(FC 502/2 X SP 581194sl) " X " "	" " H02	101				116				109		
SP 602039sl " X " "	" " H07	104				91				98		
(FC 502/2 X FC 503) " X " 59B18-0	" 641202H01	94				100		114	87	97		101
(FC 502/2 X SP 581194sl) " X " "	" 641202H02	91				109		134	92	100		113
(FC 502/2 X FC 504) " X " "	" " H03	99				118		127	111	109		119
(SP 581194sl X FC 504) " X " "	" " H04	97				117		106	106	107		106
SP 602082sl " X " "	" " H09	91				106				99		
SP 602009sl " X " "	" " H014	100				97				99		
FC 505 (SP 602063sl) " X " "	" " H015	105				114				110		
(FC 502/2 X FC 503) " X " 621160-00	" 641203H01	65				95				80		
(FC 502/2 X SP 581194sl) " X " "	" " H02	84				105				95		
(FC 502/2 X FC 504) " X " "	" " H03	85				105				95		
(SP 581194sl X FC 504) " X " "	" " H04	82				101				92		
(FC 502/2 X FC 503) " X FC 901	" 641204H01							103	88			96
(FC 502/2 X SP 581194sl) " X " "	" " H02		102	93	98		95	110	107		98	109
(FC 502/2 X FC 504) " X " "	" " H03							116	98			107
(SP 581194sl X FC 504) " X " "	" " H04		104	105	83		103	121	99		100	110
FC 502/2 " X " "	" " H05						99					
SP 602039sl " X " "	" " H07		102	93	81		95				95	
SP 602009sl " X " "	" " H014		90	103	88		97				94	
FC 504 " X " "	" " H019		106	88	100		103				101	
(FC 502/2 X FC 503) " X S-62-16 (4n)	" 641205H01		77	95	96		99	98	101		91	100
(FC 502/2 X SP 581194el) " X " "	" " H02						100					
(FC 502/2 X FC 504) " X " "	" " H03		90	105	92		111				100	
(FC 502/2 X FC 503) " X S-63 pool (4n)"	641206H01		90	104	92		102				97	
Local check 1		82	89	94	94	125	92	87	73	104	92	80
Local check 2							77	110	101			106
LSD (.05)[c]		15	15	22	28	25	11					
Variety no. of local check 1		Am. 2 Mono.	Am. 2 Mono.	Am. 2 Mono.	Am. 2 Mono.	Am. 3S Mono.	HH 10	SP 5822-0	SP 5822-0			
Variety no. of local check 2							HH 12	US H6	US H6			

a/ In computing the indicated averages, locations 2 and 3 were combined and considered as a single location.

b/ Disease exposure considered sufficient to affect harvest results appreciably: LS = Cercospora leaf spot; CT = curly top; Rh = Rhizoctonia root rot. Estimated severity of disease exposure (editor's opinion): 1 = mild; 2 = moderate; 3 = severe.

c/ LSD (.05) expressed as percent of the gross sucrose yield of the standard variety.

Table 12 .--Summary of harvest results of cooperators' agronomic evaluation tests of experimental hybrids, 1965; as percent of the standard variety, SL (129 X 133) MS X SP 5822-0.

Root Yield

Description	Seed no.	1-a R.F. Colo.	1-b R.F. Colo.	2 John. Kan.	3 G.C. Kan.	4 M.C. Ia.	5 Herf. Tex.	6 Wes. Tex.	7 Prog. Tex. 4/12	Av. 1-a & 4	Av.[a] 1-b, 2, 3 & 5	Ave. 6 & 7
Disease exposure[b]		LS-1 Rh-1	LS-1 Rh-1			LS-1 Rh-1	LS-3 CT-3	LS-2	LS-1			
No. of replications		9	12	3	3	9	9	4	4			
(FC 502/2 X FC 503) MS X SP 5822-0	SP 641201H01	88				107				98		
(FC 502/2 X SP 581194sl) " X " "	" " H02	96				108				102		
SP 602039sl " X " "	" " H07	106				92				99		
(FC 502/2 X FC 503) " X " 59B18-0	" 641202H01	88				100		123	85	94		104
(FC 502/2 X SP 581194sl) " X " "	" " H02	87				109		144	90	98		117
(FC 502/2 X FC 504) " X " "	" " H03	96				115		132	105	106		119
(SP 581194sl X FC 504) " X " "	" " H04	92				111		117	96	102		107
SP 602082sl " X " "	" " H09	86				106				96		
SP 602009sl " X " "	" " H014	93				97				95		
FC 505 (SP 602063sl) " X " "	" " H015	98				112				105		
(FC 502/2 X FC 503) " X " 621160-00	" 641203H01	63				94				79		
(FC 502/2 X SP 581194sl) " X " "	" " H02	79				105				92		
(FC 502/2 X FC 504) " X " "	" " H03	81				102				92		
(SP 581194sl X FC 504) " X " "	" " H04	80				102				91		
(FC 502/2 X FC 503) " X FC 901	" 641204H01							108	82			95
(FC 502/2 X SP 581194sl) " X " "	" " H02		100	88	87		94	108	95		94	102
(FC 502/2 X FC 504) " X " "	" " H03							122	103			113
(SP 581194sl X FC 504) " X " "	" " H04		104	106	78		103	124	94		100	109
FC 502/2 " X " "	" " H05						97					
SP 602039sl " X " "	" " H07		104	97	78		100				97	
SP 602009sl " X " "	" " H014		87	95	77		97				90	
FC 504 " X " "	" " H019		108	94	99		104				103	
(FC 502/2 X FC 503) " X S-62-16 (4n) "	641205H01		82	98	95		100	104	102		93	103
(FC 502/2 X SP 581194sl) " X " " "	" H02						98					
(FC 502/2 X FC 504) " X " " "	" H03		98	109	89		112				103	
(FC 502/2 X FC 503) " X S-63 pool (4n)"	641206H01		92	108	91		101				98	
Local check 1		81	87	92	87	129	96	104	83	105	91	94
Local check 2							79	122	102			112
LSD (.05)[c]		14	15	21	26	23	10	28	18			
Variety no. of local check 1		Am. 2 Mono.	Am. 2 Mono.	Am. 2 Mono.	Am. 2 Mono.	Am. 3S Mono.	HH 10	SP 5822-0	SP 5822-0			
Variety no. of local check 2							HH 12	US H6	US H6			

[a] In computing the indicated averages, locations 2 and 3 were combined and considered as a single location.

[b] Disease exposure considered sufficient to affect harvest results appreciably: LS = Cercospora leaf spot; CT = curly top; RH = Rhizoctonia root rot. Estimated severity of disease exposure (editor's opinion): 1 = mild; 2 = moderate; 3 = severe.

[c] LSD (.05) expressed as percent of the root yield of the standard variety.

Table 13 .--Summary of harvest results of cooperators' agronomic evaluation tests of experimental hybrids, 1965; as percent of the standard variety, SL (129 X 133) MS X SP 5822-0.

Sucrose Percentage

Description	Seed no.	1-a R.F. Colo.	1-b R.F. Colo.	2 John. Kan.	3 G.C. Kan.	4 M.C. Ia.	5 Herf. Tex.	6 Wes. Tex.	7 Prog. Tex. 5/5	Av.[a] 1-a & 4	Av.[a] 1-b,2, 3 & 5	Av.[a] 6 & 7
	Disease exposure[b]	LS-1 Rh-1	LS-1 Rh-1			LS-1 Rh-1	LS-3: CT-3	LS-2	LS-1			
	No. of replications:	9	12	3	3	9	9	4	4			
(FC 502/2 X FC 503) MS X SP 5822-0	SP 641201H01	104				102				103		
(FC 502/2 X SP 581194sl) " X "	" " H02	106				107				107		
SP 602039sl " X "	" " H07	99				98				99		
(FC 502/2 X FC 503) " X " 59B18-0	" 641202H01	107				100		93	109	104		101
(FC 502/2 X SP 581194sl) " X " "	" " H02	105				101		93	104	103		99
(FC 502/2 X FC 504) " X " "	" " H03	103				103		96	103	103		100
(SP 581194sl X FC 504) " X " "	" " H04	106				105		90	109	106		100
SP 602082sl " X " "	" " H09	106				100				103		
SP 602009sl " X " "	" " H014	108				100				104		
FC 505 (SP 602063sl) " X " "	" " H015	108				102				105		
(FC 502/2 X FC 503) " X " 621160-00	" 641203H01	104				101				103		
(FC 502/2 X SP 581194sl) " X " "	" " H02	106				99				103		
(FC 502/2 X FC 504) " X " "	" " H03	105				103				104		
(SP 581194sl X FC 504) " X " "	" " H04	102				99				101		
(FC 502/2 X FC 503) " X FC 901	" 641204H01							96	107			102
(FC 502/2 X SP 581194sl) " X " "	" " H02		102	106	113		102	103	112		105	108
(FC 502/2 X FC 504) " X " "	" " H03							96	104			100
(SP 581194sl X FC 504) " X " "	" " H04		100	99	107		100	98	107		101	103
FC 502/2 " X " "	" " H05						102					
SP 602039sl " X " "	" " H07		98	96	104		94				97	
SP 602009sl " X " "	" " H014		104	108	113		100				105	
FC 504 " X " "	" " H019		99	94	100		99				98	
(FC 502/2 X FC 503) " X S-62-16 (4n)	" 641205H01		94	96	101		99	94	101		97	98
(FC 502/2 X SP 581194sl) " X " "	" " H02						102					
(FC 502/2 X FC 504) " X " "	" " H03		92	96	103		99				97	
(FC 502/2 X FC 503) " X S-63 pool (4n)	" 641206H01		98	97	101		101				99	
Local check 1		101	102	102	109	97	96	84	94	99	101	89
Local check 2							97	90	95			93
LSD (.05)[c]		3	3	7	6	8	3	11	6			
Variety no. of local check 1		Am. 2 Mono.	Am. 2 Mono.	Am. 2 Mono.	Am. 2 Mono.	Am. 3S Mono.	HH 10	SP 5822-0	SP 5822-0			
Variety no. of local check 2							HH 12	US H6	US H6			

a/ In computing the indicated averages, locations 2 and 3 were combined and considered as a single location.

b/ Disease exposure considered sufficient to affect harvest results appreciably: LS = Cercospora leaf spot; CT = curly top; RH = Rhizoctonia root rot. Estimated severity of disease exposure (editor's opinion): 1 = mild; 2 = moderate; 3 = severe.

c/ LSD (.05) expressed as percent of the sucrose percentage of the standard variety.

Agronomic Evaluation of LSR-CTR Monogerm, Type-0, Inbred Lines

Several monogerm, type-0 or near type-0, inbred lines, thought to possess some resistance to both leaf spot and curly top, were evaluated in the leaf spot field at Fort Collins and under curly top conditions at Thatcher, Utah. The latter work was conducted by A. M. Murphy, U. S. Department of Agriculture, Logan, Utah, and is described briefly in the tables of results.

The tests at Fort Collins were of two types. In one of these (Experiment 5A), the inbred lines themselves were compared with check material using a modified randomized-block design with 3 replications. Plots were 4 rows wide and 20 feet long, and the 2 inner rows were harvested for yield and sucrose determinations. Yield data for the inbred lines are considered to have relatively little value, but sucrose percentages may be important as an indication of their potential value.

The other Fort Collins test (Experiment 10A), was designed to appraise the general combining ability of the lines by using the LSR-CTR variety, FC 901, as a common parent. Since fairly representative male-sterile equivalents of the inbreds were not available, hybridizations had been made using aa (i.e. Mendelian male sterile) segregants in FC 901 as the female parent in each of a series of matings with the inbred lines. The resulting hybrids (seed harvested in the greenhouse in the spring of 1965) were compared with check material in Experiment 10A using a randomized-block design, 1-row x 20-ft. plots, and 9 replications. The test was planted rather late.

The results of Experiments 5A and 10A at Fort Collins are presented in Tables 14 and 15, respectively, together with the curly top resistance data from Thatcher, Utah. Considering the leaf spot, curly top, and sucrose percentage data shown for the inbreds themselves (Table 14), three lines appear promising, namely FC 601, SP 632028sl, and SP 632090slcl, though the low sucrose percentage for the last of these three places it in doubt. The results for the hybrids (Table 15) are very encouraging in that each of the hybrids involving FC 601 and SP 632028sl was (a) approximately equivalent to FC (502/2 x 504) CMS♀ x FC 901 in yields of roots and gross sucrose and in sucrose percentage at Fort Collins, in the absence of curly top; (b) at least as high in leaf spot resistance as the latter hybrid; and (c) about equal to US 41 in curly top resistance. In making comparisons with FC (502/2 x 504) CMS♀ x FC 901 in Experiment 10A, it should be noted that this hybrid showed moderate resistance to leaf spot and surpassed the standard variety, SL (129 x 133) CMS x SP 5822-0, by highly significant amounts in yield of roots and gross sucrose and in sucrose percentage. It is noteworthy that, in line with its performance as an inbred (in Experiment 5A), the hybrid of SP 632090slcl (in Experiment 10A) was low in sucrose percentage relative to the hybrids of FC 601 and SP 632028sl. Evaluation of the type-0 character in the latter 2 lines has not yet been completed, but at this point each line appears to be either completely type-0 or nearly so.

Table 14 .--Preliminary evaluation of monogerm, type-0, LSR-CTR inbred lines at Fort Collins, Colorado, and Thatcher, Utah, 1965.

Description	Ft. Collins seed no.	Ft. Collins, Colo. (Exp. 5A), 3-plot averages: Acre yield Gross suc.	Acre yield Roots	Sucrose	Leaf spot[a/] 8/23	Leaf spot[a/] 9/1	Vig.[b/] 8/12	Plants per 100'	Thatcher, Utah[c/]: Curly top % 9/15	Curly top Grade[d/] 10/1	Plants per 100'
		Lbs.	Tons	%				No.			No.
	I. Monogerm, type-0 (±), LSR-CTR inbred lines										
SP 632028sl (S_1 from SP 611101-0)	SP 651151HOA	2619	8.83	14.83	2.2	3.5	6.0	128	36	3.0	88
SP 632090slcl (S_1 " " ")	SP 651152HO	2199	8.33	13.20	1.7	1.8	6.3	125	55	3.0	88
SP 612070slcl (S_2 from US 201 x SLC 91)	SP 651154HO[e/]								67	6.0	42
SP 622027sl (S_1 from SP 611100-0)	SP 641155HOA								79	5.0	84
SP " ; SP 641155HOA	SP 651155HOA	1506	5.31	14.22	1.5	2.2	5.0	125	85	6.0	54
FC 601 (SP 622071sl; S_1 from SP 611101-0)	SP 641156HOA								79	5.0	84
FC " ; SP 641156HOA	SP 651156HOA	1908	7.12	13.40	1.2	1.2	5.3	120	39	3.5	66
	II. Checks										
FC 502/2 (mm, type-0, LSR inbred)	SP 641207HO	3112	9.59	16.23	1.0	1.8	5.3	131			
US 201 (MM)	SP 5810[illegible]1-0	1727	6.00	14.38	1.0	1.2	6.0	124			
Synthetic Check (MM)	Acc. 2269	2267	8.83	12.83	7.2	7.2	6.7	122			
SP 5481-0 (MM)	Acc. 2483	2361	8.58	13.73	4.5	4.3	7.0	118	84	5.5	106
SP 6051-0 (MM)	SP 631210HO								63	4.0	94
US 33									84	4.8	86
US 41									45	3.3	98

a/ Leaf spot grades: 0 = no leaf spot; 10 = complete defoliation.

b/ Foliage vigor: Larger no. = gre[illegible] vigor.

c/ Results at Thatcher (furnished by A. M. Murphy) were based on a minimum of one 50' row for each line.

d/ Curly top grades: 0 = healthy; 9 = death due to curly top.

e/ The preceding generation (SP 631170HO), evaluated under leaf spot conditions in 1964, was found to have excellent leaf spot resistance and acceptable sucrose percentage, root size, and foliage vigor.

Table 15 .--Evaluation of experimental LSR-CTR hybrids at Fort Collins, Colorado, and Thatcher, Utah, 1965.

Description[a]	Ft. Collins seed no.	Ft. Collins, Colo. (Exp. 10A) 9-plot avs.: Acre yield, Gross sucr.	Acre yield, Roots	Sucrose	Leaf spot[b] 8/23	Leaf spot[b] 9/1	Plants per 100'	Thatcher, Utah[c]: Curly top % 9/15	Curly top Grade[d] 10/1	Plants per 100'
		Lbs.	Tons	%			No.			No.
FC 901 aa ♀ X SP 632028sl mm	SP 651151H02	3369	11.10	15.16	2.7	2.8	117	64	3.0	116
" " " " X SP 632090slcl mm	SP 651152H02	3073	10.78	14.24	2.4	2.4	114	62	3.0	110
" " " " X SP 612070slcl "	SP 651154H02	2720	8.97	15.19	2.8	2.9	113	83	5.0	94
" " " " X SP 622027sl mm	SP 651155H02	2640	9.04	14.60	3.4	3.9	113	55	4.0	106
" " " " X SP 622071sl (FC 601) mm	SP 651156H02	3175	10.49	15.14	2.3	2.4	120	51	3.0	105
FC (502/2 x 503) mm CMS ♀ X FC 901	SP 641204H01	3398	11.02	15.42	2.9	3.3	111	74	4.0	95
FC (502/2 x 504) mm " " X " "	SP 641204H03	3221	10.62	15.16	3.1	3.1	115	74	4.0	89
SL (129 x 133) mm CMS X SP 5822-0	Acc. 2634	2434	8.52	14.23	4.2	4.5	114	77	4.0	100
SP 5481-0	Acc. 2483							84	5.5	106
SP 6051-0	SP 631210H0							63	4.0	94
US 33								84	4.8	86
US 41								45	3.3	98
General mean		3004	10.07	14.90	3.0	3.2	115			
S. E. of var. mean		94.30	0.3123	0.1179	0.17	0.17	3.02			
S. E. of var. mean as % of gen. mean		3.14	3.10	0.79	5.87	5.48	2.64			
L.S.D. (.05)		267	0.88	0.33	0.5	0.5	9			
F (varieties)		14.58**	11.14**	15.61**	11.64**	17.23**	0.83			

a/ Lines are multigerm (MM) except where otherwise indicated.

b/ Leaf spot grades: 0 = no leaf spot; 10 = complete defoliation.

c/ Results at Thatcher (furnished by A. M. Murphy) were based on a minimum of one 50' row for each variety; mostly on two or more 50' rows per variety.

d/ Curly top grades: 0 = healthy; 9 = death due to curly top.

** F exceeds the 1% point.

Observational Evaluation of LSR-CTR Monogerm, Type-0, Inbred Lines

An essential step in the development of LSR-CTR, monogerm, type-0, inbred lines is the observational evaluation of resistance to leaf spot and curly top using seed obtained directly from selfing by means of paper bags. Thirty three such seed lots, obtained in 1964, were shared with C. L. Schneider, U. S. Department of Agriculture, Logan, Utah, for curly top resistance determinations in the greenhouse. Seed of each of those lines also was planted in field plots at Fort Collins under severe leaf spot exposure. Essential details of the techniques employed at the two locations are given in the table of results (Table 16).

The use of the backcross method to produce some of the source material (SP 611100-0 and SP 611101-0), designated in Table 16, is described on page 187 of the 1963 progress report on this project (2). Other source material is described in Table 16.

The high resistance to both leaf spot and curly top, shown for 3 of the 4 sub-lines of the type-0 line, FC 601 (entries 328-334), is of special interest. In addition to those numbers, 11 lines, tentatively classed as type-0 or near-type-0, were at least equal to SP 5481-0 in leaf spot resistance and to US 41 in curly top resistance.

It should be noted that the 4 S_1 lines obtained directly from SP 611227-(001) were given average curly top grades ranging from 108 to 123. In contrast with those lines, one of the 7 S_1 lines obtained from SP 631103-0 was given an average grade of 104 and the other 6 ranged from 88 to 98. SP 611227-(001) presumably is segregating for curly top resistance, and it appears that the curly top resistance selection work performed in that material, while in the seedling stage, by C. W. Bennett, giving rise to SP 631103-0, may have improved the general level of resistance of the material.

Table 16 .--Evaluation of leaf spot and curly top resistance of monogerm, type-0 and near-type-0, inbred lines of sugarbeet, Fort Collins, Colo., and Logan, Utah, 1965.

Description and/or source	Immediate parent	Strain no. (seed no.)	No. gen. self.	Pol. rating[a]	O-rating[b]	Ft. Collins exp. no. 6A[c]: Entry no.	No. of plots	Leaf spot[e] 8/25	Leaf spot[e] 9/3	Vig.[f] 8/9-10	Logan greenhouse[d]: Code no.	No. infect. plants	Curly top[g]
SP 611100-0	SP 622027sl	SP 642009sl	2	4	95/0	301	1	0.5	0.5	5.0	65-1	18	110
" "	" "	SP 642010sl	2	4	92/0	303	2	1.8	1.8	5.0	65-2	20	104
" "	SP 622075sl	SP 642027sl	2	5	96/0	307	2	1.8	2.5	6.0	65-4	20	75
" "	SP 622105sl	SP 642087sl	2	5	95/5	313	2	2.8	3.5	6.5	65-5	19	102
" "	SP 622107sl	SP 642094sl	2	5	90/0	317	1	1.0	2.0	5.0	65-6	17	133
" "	" "	SP 642101sl	2	5	95/0	319	2	1.0	1.0	5.0	65-7	20	112
" "	" "	SP 642107sl	2	5	90/0	321	1	3.0	4.0	5.0	65-8	19	112
" "	SP 622112sl	SP 642063sl	2	4	95/0	322	2	2.3	3.0	5.0	65-9	17	81
" "	" "	SP 642064sl	2	5	100/0	324	2	1.8	2.5	5.0	65-10	18	117
" "	" "	SP 642072sl	2	5	95/0	326	2	1.5	2.3	4.5	65-11	17	106
SP 611101-0	SP 622071sl[h]	SP 642032sl	2	6	100/0	328	1	1.5	1.5	6.0	65-12	17	89
" "	" "	SP 642050sl	2	5	100/0	330	1	2.0	3.0	5.0	65-13	18	100
" "	" "	SP 642056sl	2	4	100/0	332	2	1.8	1.8	5.5	65-14	17	80
" "	" "	SP 642065sl	2	3	100/0	334	2	1.3	2.3	5.0	65-15	19	93
" "	SP 622076sl	SP 642102sl	2	4	95/0	340	2	4.0	4.0	5.5	65-16	19	106
" "	SP 622101sl	SP 642049sl	2	5	100/0	342	1	1.5	2.0	6.0	65-17	20	100
" "	" "	SP 642090sl	2	6	100/0	344	1	1.5	2.0	5.0	65-18	18	104
SP 611100-0	SP 631101-0A	SP 642044sl	1	6	96/0	353	1	1.5	3.0	5.0	65-20	20	131
" "	" "	SP 642054sl	1	6	92/0	357	2	1.0	2.0	6.5	65-21	19	92
" "	" "	SP 642082sl	1	6	100/0	361	2	1.0	1.0	6.5	65-22	16	90
" "	" "	SP 642089sl	1	6	92/0	363	2	1.8	2.0	6.5	65-23	18	98
" "	" "	SP 642093slcl	1	3	88/0	367	1	2.0	2.5	7.0	65-24	16	96
LSR-CTR pool[i]	SP 611227-(001)	" 642017sl	1	5	88/0	369	2	2.5	3.3	5.0	65-25	20	110
" " "	" "	SP 642028sl	1	6	100/0	371	2	2.5	4.0	6.0	65-26	19	123
" " "	" "	SP 642052sl	1	6	96/0	375	2	6.0	5.0	5.0	65-27	20	108
" " "	" "	SP 642077sl	1	6	100/0	377	2	1.0	1.5	6.0	65-28	9	110
SP 611227-(001)	SP 631103-0[j]	SP 642004sl	1	5	91/0	379	2	3.5	4.5	6.0	65-29	12	88
" "	" "	SP 642033sl	1	5	100/0	384	2	2.5	2.5	6.0	65-31	10	104
" "	" "	SP 642047sl	1	6	92/0	390	2	1.8	1.8	5.5	65-32	12	90
" "	" "	SP 642079sl	1	6	91/0	392	2	2.0	2.3	6.5	65-33	10	98
" "	" "	SP 642085sl	1	6	96/0	395	2	3.3	3.5	5.0	65-34	8	96
" "	" "	SP 642096sl	1	6	100/0	398	2	2.0	2.0	5.5	65-35	11	96
" "	" "	SP 642097sl	1	6	96/4	400	2	2.5	2.5	6.5	65-36	9	96
SP 5481-0		Acc. 2483				404	9	2.4	3.1	6.9	65-42	15	142
SP 6051-0		SP 631210HO									65-43	16	102

a/ Quantity of pollen shed by the individual plant that was selfed to produce the indicated seed no. Basis of grades: 1-7 in ascending order of abundance (ordinary, open-pollinated, commercial variety usually rated 6 or 7).

b/ Pertains to the indexing population (at least 20 plants); left number is percentage classed as male sterile; right number is percentage classed as male fertile; percentage unaccounted for, if any, represents intermediate types.

c/ Field plots on Hospital Farm, Ft. Collins, Colo.; inoculation and frequent sprinkling used to promote leaf spot development; plots 1 row x 20', flanked uniformly by rows of a leaf spot susceptible strain.

d/ Curly top resistance evaluation by C. L. Schneider, Logan, Utah, using greenhouse seedling technique with Schneider's culture A1A of the curly top virus, 20 plants for each code no., and 2 caged leafhoppers per plant.

e/ Leaf spot grades (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

f/ Foliage vigor (J. A. Elder): Larger no. = greater vigor.

g/ Curly top severity (C. L. Schneider). The plants were classified individually on a scale of 0 - 9 (0 = no symptoms, 9 = dead). Plants without curly top symptoms were disregarded. Results for plants with curly top symptoms were averaged by strains, and the averages were converted to percent of US 41. Thus, values less than 100 (shown above) indicate less curly top injury than in US 41, and values greater than 100 indicate more curly top injury than in US 41.

h/ FC 601.

i/ An LSR-CTR pool without US 201 blood.

j/ Seed produced at Ft. Collins, using plants selected for curly top resistance, while in the early seedling stage, by C. W. Bennett, Salinas, California.

Cooperative Evaluation Tests of LSR-CTR Varieties

Seed supplies of entries 1 through 7, as listed in Table 17, were assembled at Fort Collins and distributed to cooperators who conducted and reported results for the evaluation tests listed below. Agronomic tests at two other locations were abandoned because of flood damage, poor stand, or other misfortunes.

State	Locality	Type[a/]	Agency conducting test	Table
Calif.	Hamilton City	A	Holly Sugar Corp.	22(a), 22(b)
"	N. Tracy	A	" " "	21(a), 21(b)
Colo.	Fort Collins	A	U. S. Dept. of Agr.	23(a), 23(b)
"	Rocky Ford	A	Amer. Crystal Sug. Co.	24(a), 24(b)
Iowa	Mason City	A	" " " "	32(a), 32(b)
Kan.	Garden City	A	" " " "	26(a), 26(b)
"	Johnson	A	" " " "	27(a), 27(b)
"	Tribune	A	Kan. Agr. Exp. Station & National Sugar Mfg. Co.	25(a), 25(b)
Md.	Beltsville	A	U. S. Dept. of Agr.	33
Minn.	Moorhead	A	Amer. Crystal Sug. Co.	31(a), 31(b)
N. M.	Artesia	A	N. M. Agr. Exp. Station	30(a), 30(b)[b/]
Okla.	Goodwell	A	Okla. " " "	28(a), 28(b)
Texas	Hereford	A	Holly Sugar Corp.	29(a), 29(b)
Utah	Logan	0	U. S. Dept. of Agr.	34
"	Thatcher	0	" " " " "	34

a/ Type of test: A = agronomic; 0 = observational.

b/ Also see Figure 1.

Results for the individual tests are shown in the tables and figure listed above, and a general summary of agronomic data is presented in Tables 18, 19, and 20 together with estimates of disease exposure. Because of the wide range in the severity of leaf spot and curly top exposures at the various locations, average performance figures for the LSR check (SP 5822-0) and the CTR check (US H6) mean little. Examination of the averages for certain other entries reveals the following important trends or relationships:

1. With SL(129 x 133) MS serving as the female, SP 6322-0 was substantially superior to SP 5822-0 for use as the pollinator. The average gross sucrose yield for entry no. 3 [SL (129 x 133) MS x SP 6322-0] was 107.0% of that of entry no. 1 [SL (129 x 133) MS x SP 5822-0], and there was essentially no difference in average sucrose percentage.

2. The outstanding hybrid in the entire series, in yield of gross sucrose, was entry no. 5 [FC (502/2 x 504) MS x FC 901], and its average sucrose percentage was relatively high. The average

gross sucrose yield and sucrose percentage for entry 5 were 108.4 and 102.5 percent of the corresponding averages for the standard variety, entry no. 1. Entry no. 3, described above, was the only close competitor of no. 5 in gross sucrose yield, and it was no better than the standard variety in sucrose percentage. Thus it was concluded that, under the array of conditions represented by these tests, FC (502/2 x 504) MS x FC 901 (entry 5) was substantially superior to all other entries, 1 through 4, in the combination of abilities to produce high gross sucrose yield with high sucrose percentage.

3. In order to put the above comparisons in proper perspective, it should be noted that the average gross sucrose yield and average sucrose percentage for entry no. 8 (local check), expressed as percent of the corresponding averages for entry no. 1 (standard variety), were 103.2 and 100.1, respectively. Furthermore, it should be recalled (a) that the current standard variety, SL (129 x 133) MS x SP 5822-0, exceeded SL 126 MS x SP 5460-0, in the 1964 cooperative test series, by an average of about 3% in gross sucrose yield (3); and (b) that the latter hybrid exceeded SL 122 MS x SP 5460-0 by 11% in gross sucrose yield in both the 1962 and 1963 cooperative test series (1, 2).

As shown in Tables 23(b), 33, and 20-A, entries 1 through 5 were roughly intermediate, between resistant and susceptible checks, in levels of resistance to both leaf spot and curly top. Specifically, entry 5 was about the same as entry 1 in curly top resistance and measurably better in leaf spot resistance.

Literature Cited

(1) Gaskill, John O., et al. Development and evaluation of sugarbeet breeding material and varieties carrying resistance to leaf spot and curly top, 1962. Sugarbeet Research, 1962 Report (CR-4-63, Crops Research Division, Agricultural Research Service, U. S. Dept. of Agriculture): 139-160.

(2) Same as above, but for 1963. Sugarbeet Research, 1963 Report (CR-4-64): 179-210.

(3) Same as above, but for 1964. Sugarbeet Research, 1964 Report. Forty one pages (in press).

Table 17 .--Description of material in cooperative agronomic evaluation tests of LSR-CTR varieties, 1965.

Entry no.	Ft. Collins seed no.	Description and supplier[a/]
1	Acc. 2634	SL (129 X 133) MS X SP 5822-0; monogerm; LSR-CTR; Farmers & Manufacturers Beet Sugar Assoc. and West Coast Beet Seed Co. (WC lot 4475).
2	Acc. 2635	CT 5 MS X SP 5822-0; monogerm; LSR-CTR; F. & M. and West Coast Beet Seed Co. (WC lot 4494).
3	Acc. 2636	SL (129 X 133) MS X SP 6322-0; monogerm; LSR-CTR; F. & M. and West Coast Beet Seed Co. (WC lot 4567).
4	SP 641204H01	FC (502/2 X 503) MS X FC 901; monogerm; LSR-CTR; Sugarbeet Investigations, Fort Collins, Colo.
5	SP 641204H03	FC (502/2 X 504) MS X FC 901; monogerm; LSR-CTR; Sugarbeet Investigations, Fort Collins, Colo.
6	Acc. 2623	SP 5822-0; a multigerm, U.S.D.A. variety, resistant to leaf spot and black root, developed for use in eastern sugarbeet areas; included in these cooperative tests as an LSR check; seed furnished by G. E. Coe, U.S.D.A., Beltsville, Md.
7	Acc. 2633	US H6; a multigerm, U.S.D.A. variety, resistant to curly top and bolting, developed for use in California; included in these tests as a CTR check; seed furnished by J. S. McFarlane, U.S.D.A., Salinas, Calif.
8		Local check; furnished by cooperator.
9		Local check; furnished by cooperator (occasional).

a/ The parental lines listed were developed by various U.S.D.A. stations and may be described as follows:

Line	Seed type	Resistant to: Curly top	Leaf spot	Black root
CT 5	mono.	X		
SL 129 and 133	mono.	X		
SP 5822-0 and 6322-0	multi.		X	X
FC 502/2, 503,& 504	mono.		X	
FC 901	multi.	X	X (mod.)	

Table 18 .--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1965; as percent of the standard variety, SL (129 X 133) MS X SP 5822-0.

Gross Sucrose Yield

Location	Diseases a/	No. reps.	Entry no. 1	2	3	4	5	6	7	8 b/	9 b/	LSD c/ (.05)
(1) N. Tracy, Calif.		8	100	110	106	100	106	95	92	99		10
(2) Hamilton City, Calif.	LS-1?	8	100	104	104	115	113	77	103	112		14
(3) Ft. Collins, Colo.	LS-3	9	100	97	107	119	113	94	94	104	94	5
(4) Rocky Ford, Colo.	LS-1, Rh-2	9	100	124	119	112	104	119	77	94	103	24
(5) Tribune, Kan.		9	100	113	106	103	109	99	106	106	106	12
(6) Garden City, Kan.		3	100	110	103	88	100	92	100	96	93	25
(7) Johnson, Kan.		3	100	101	120	105	102	94	100	90	95	18
(8) Goodwell, Okla.	CT-1, LS-1	10	100	106	103	106	114	101	88	128		13
(9) Hereford, Tex.	CT-3, LS-3	9	100	115	110	96	111	71	101	103	89	6
(10) Artesia, N.M.	CT-3+, LS-1	4	100	95	93	97	105	49	98	128	134	
(11) Moorhead, Minn.	LS-1?	9	100	103	113	105	111	96	120	109	94	15
(12) Mason City, Ia.	LS-1?, Rh-1?	9	100	106	100	97	112	95	126	94	110	24
(13) Beltsville, Md.	BR-?, LS-3	3	100	75	107	98	109	105	68	78		20
Average			100.0	104.5	107.0	103.2	108.4	91.3	97.9	103.2		

a/ Disease exposure considered sufficient to affect harvest results appreciably; BR = black root (*Aphanomyces cochlioides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); Rh = Rhizoctonia root rot. Estimated severity of disease exposure (editor's opinion): 1 = mild; 2 = moderate; 3 = severe.

b/ The local checks, entries 8 and 9, were as follows, respectively (location numbers in parentheses): (1) HH 8; (2) HH 9; (3) GW 674-56C and SL (126 X 128) MS X SP 5822-0; (4) Am 2 Mono and Am 2 Multi; (5) SL (126 X 128) MS X SP 5822-0 and G.W.S. Co. monogerm; (6) Am 2 Mono and Am 2 Multi; (7) same as (6); (8) HH 10; (9) HH 10 and HH 12; (10) HH 10 and Holly 3227-05; (11) Am 3 S Mono and Am 3 N Multi; (12) Am 3 S Mono and Am 3 S Multi; (13) SP 64100-05.

c/ LSD (.05) expressed as percent of the gross sucrose yield of the standard variety.

Table 19.--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1965; as percent of the standard variety, SL (129 X 133) MS X SP 5822-0.

Root Yield

	Location	Diseases[a/]	No. reps.	Entry 1	2	3	4	5	6	7	8[b/]	9[b/]	LSD[c/] (.05)
(1)	N. Tracy, Calif.		8	100	113	109	96	104	99	97	100		9
(2)	Hamilton City, Calif.	LS-1?	8	100	110	107	115	108	80	107	122		11
(3)	Ft. Collins, Colo.	LS-3	9	100	99	107	113	109	96	98	104	94	5
(4)	Rocky Ford, Colo.	LS-1, Rh-2	9	100	126	123	109	106	119	84	100	102	24
(5)	Tribune, Kan.		9	100	112	106	100	107	98	108	103	100	10
(6)	Garden City, Kan.		3	100	106	93	83	90	88	96	89	86	22
(7)	Johnson, Kan.		3	100	102	116	106	100	98	100	91	98	16
(8)	Goodwell, Okla.	CT-1, LS-1	10	100	115	107	107	113	95	101	127		9
(9)	Hereford, Tex.	CT-3, LS-3	9	100	115	109	94	110	72	104	105	91	6
(10)	Artesia, N. M.	CT-3+, LS-1	4	100	92	101	93	105	42	134	114	119	23
(11)	Moorhead, Minn.	LS-1?	9	100	106	112	100	109	101	121	106	97	15
(12)	Mason City, Ia.	LS-1?, Rh-1?	9	100	104	96	95	104	93	132	90	113	23
(13)	Beltsville, Md.	BR-?, LS-3	3	100	82	110	99	115	106	81	91		22
Average				100.0	106.3	107.4	100.8	106.2	91.3	104.8	103.2		

a/ Disease exposure considered sufficient to affect harvest results appreciably: BR = black root (*Aphanomyces cochlioides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); Rh = Rhizoctonia root rot. Estimated severity of disease exposure (editor's opinion): 1 = mild; 2 = moderate; 3 = severe.

b/ The local checks, entries 8 and 9, were as follows, respectively (location numbers in parentheses): (1) HH 8; (2) HH 9; (3) GW 674-56C and SL (126 X 128) MS X SP 5822-0; (4) Am 2 Mono and Am 2 Multi; (5) SL (126 X 128) MS X SP 5822-0 and G.W.S. Co. monogerm; (6) Am 2 Mono and Am 2 Multi; (7) same as (6); (8) HH 10; (9) HH 10 and HH 12; (10) HH 10 and Holly 3227-05; (11) Am 3 S Mono and Am 3 N Multi; (12) Am 3 S Mono and Am 3 S Multi; (13) SP 64100-05.

c/ LSD (.05) expressed as percent of the root yield of the standard variety.

Table 20 .--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1965; as percent of the standard variety, SL (129 X 133) MS X SP 5822-0.

Sucrose Percentage

Location	Diseases[a/]	No. reps.	Entry no. 1	2	3	4	5	6	7	8[b/]	9[b/]	LSD[c/] (.05)
(1) N. Tracy, Calif.		8	100	98	97	104	102	97	95	99		5
(2) Hamilton City, Calif.	LS-1?	8	100	95	97	100	104	96	96	92		8
(3) Ft. Collins, Colo.	LS-3	9	100	99	101	106	104	98	96	100	100	1
(4) Rocky Ford, Colo.	LS-1, Rh-2	9	100	98	97	103	99	100	92	94	101	5
(5) Tribune, Kan.		9	100	101	101	103	102	102	98	103	106	4
(6) Garden City, Kan.		3	100	103	110	106	111	105	105	109	108	9
(7) Johnson, Kan.		3	100	99	104	99	102	96	100	100	102	9
(8) Goodwell, Okla.	CT-1, LS-1	10	100	92	96	99	101	106	87	101		9
(9) Hereford, Tex.	CT-3, LS-3	9	100	100	101	102	101	99	97	98	98	2
(10) Artesia, N. M.	CT-3+, LS-1	4	100	103	92	105	101	118	73	112	113	13
(11) Moorhead, Minn.	LS-1?	9	100	97	101	105	102	96	99	103	96	4
(12) Mason City, Ia.	LS-1?, Rh-1?	9	100	102	104	102	108	102	95	104	97	7
(13) Beltsville, Md.	BR-?, LS-3	3	100	93	97	99	96	99	84	86		4
Average			100.0	98.5	99.8	102.5	102.5	101.1	93.6	100.1		

a/ Disease exposure considered sufficient to affect harvest results appreciably: BR = black root (Aphanomyces cochlioides); CT = curly top (virus); LS = leaf spot (Cercospora beticola); Rh = Rhizoctonia root rot. Estimated severity of disease exposure (editor's opinion): 1 = mild; 2 = moderate; 3 = severe.

b/ The local checks, entries 8 and 9, were as follows, respectively (location numbers in parentheses): (1) HH 8; (2) HH 9; (3) GW 674-56C and SL (126 X 128) MS X SP 5822-0; (4) Am 2 Mono and Am 2 Multi; (5) SL (126 X 128) MS X SP 5822-0 and G.W.S. Co. monogerm; (6) Am 2 Mono and Am 2 Multi; (7) same as (6); (8) HH 10; (9) HH 10 and HH 12; (10) HH 10 and Holly 3227-05; (11) Am 3 S Mono and Am 3 N Multi; (12) Am 3 S Mono and Am 3 S Multi; (13) SP 64100-05.

c/ LSD (.05) expressed as percent of the sucrose percentage of the standard variety.

Table 20-A.--Cooperative curly top resistance evaluation tests of LSR-CTR varieties, Thatcher and Logan, Utah, 1965.[a]

Description	Fort Collins seed no.	Entry no.	Thatcher (field plots)[b]				Logan (greenhouse)[c]		
			C. T. inci- dence 9/15	C. T. grade: Actual 10/1[d]	C. T. grade: % of US 41	Plants per 100'	C. T. inci- dence	C. T. grade: Actual [d]	C. T. grade: % of US 41
			%			No.	%		
SL (129 X 133)MS X SP 5822-0	Acc. 2634	1	76.9	4.0	133	100	95	5.7	130
CT 5 MS X SP 5822-0	Acc. 2635	2	76.6	4.0	133	98	100	6.2	141
SL (129 X 133)MS X SP 6322-0	Acc. 2636	3	74.8	4.0	133	101	95	5.4	123
FC (502/2 X 503)MS X FC 901	SP 641204H01	4	82.0	4.5	150	102	95	5.5	125
FC (502/2 X 504)MS X FC 901	SP 641204H03	5	78.2	4.0	133	106	95	5.5	125
SP 5822-0; LSR check	Acc. 2623	6	95.2	6.0	200	104	95	7.1	161
US H6; CTR check	Acc. 2633	7	62.3	3.0	100	102	80	4.5	102
US 33			82.8	4.8	160	86	95	5.5	125
US 41			47.0	3.0	100	101	85	4.4	100

a/ Tests were conducted at Thatcher and Logan by A. M. Murphy and C. L. Schneider, respectively, U. S. Dept. of Agriculture.

b/ Plots 2 rows x 50'; each entry occurred in 2 replications; curly top exposure was intensified by artificial means.

c/ Seedling technique; curly top virus culture AlA; 20 plants per variety; 2 caged leafhoppers per plant.

d/ Basis of curly top grades: 0 = healthy; 9 = death due to curly top. In field plots, the grade represented the combined effects of curly top incidence and reaction of plants to infection. In the greenhouse, plants without curly top symptoms were disregarded.

Table 21(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, North Tracy, California, 1965.

Conducted by: D. D. Dickenson.

Location: North Tracy, California; T. Mancuso.

Cooperation: Holly Sugar Corporation.

Dates of Planting and Harvest: March 30; November 1.

Experimental Design: Latin Square, 8 X 8; plots 2 rows X 53'; rows 30" apart.

Determination of Root Yield: Two rows X 50' in each plot.

Determination of Sucrose Percentage: Two 25-pound samples per plot.

Diseases: Negligible.

Reliability of Test: Relatively good.

Table 21(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, North Tracy, California, 1965 (8-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield: Gross sucrose	Acre yield: Roots	Sucrose	Plants per 100'
			Lbs.	Tons	%	No.
SL (129 X 133) MS X SP 5822-0	Acc. 2634	1	7355	23.29	15.79	150
CT 5 MS X SP 5822-0	Acc. 2635	2	8123	26.[illegible]	15.43	143
SL (129 X 133) MS X SP 6322-0	Acc. 2636	3	7787	25.45	15.30	159
FC (502/2 X 503) MS X FC 901	SP 641204H01	4	7391	22.47	16.45	150
FC (502/2 X 504) MS X FC 901	SP 641204H03	5	7788	24.20	16.09	140
SP 5822-0; LSR check	ACC. 2623	6	6998	22.96	15.24	133
US H6; CTR check	Acc. 2633	7	6788	22.69	14.96	153
HH 8 (L.3255); local check		8	7294	23.33	15.63	148
General mean			7441	23.84	15.61	147
S. E. of var. mean			255 a/	0.717	0.26	
S. E. of var. mean as % of gen. mean			3.43	3.01	1.65	
L.S.D. (.05)			730	2.05	0.74	

Variance Table

Source of variation	D/F	Mean square (variance): Root yield	Mean square (variance): Sucrose %
Rows	7	106.451	2.52
Columns	7	7.216	0.54
Varieties	7	15.357	1.90
Error (remainder)	42	4.112	0.53
Total	63		
Calculated F value		3.74**	3.57**

a/ Short cut formula

** Exceeds 1% level, 3.10

Table 22(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Hamilton City, California, 1965.

Conducted by: D. D. Dickenson.

Location: Hamilton City, California; M. & T., Inc.

Cooperation: Holly Sugar Corporation.

Dates of Planting and Harvest: March 23; October 19.

Experimental Design: Latin Square, 8 X 8 (analyzed as randomized-block experiment); plots 2 rows X 53'; rows 30" apart.

Determination of Root Yield: Two rows X 50' in each plot.

Determination of Sucrose Percentage: Two 25-pound samples per plot.

Leaf Spot Exposure: Leaf spot began about September 1st and lasted only a month. Leaf spot should be no factor in yields or sugar.

Other Diseases: Negligible.

Reliability of Test: Relatively good.

Table -22 (b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Hamilton City, California, 1965 (8-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield: Gross sucrose	Acre yield: Roots	Sucrose	Leaf[a/] spot rating	Plants per 100'
			Lbs.	Tons	%		No.
SL (129 X 133) MS X SP 5822-0	Acc. 2634	1	5163	18.43	14.01	2.6	160
CT 5 MS X SP 5822-0	Acc. 2635	2	5381	20.26	13.28	3.1	152
SL (129 X 133) MS X SP 6322-0	Acc. 2636	3	5359	19.75	13.57	2.3	151
FC (502/2 X 503) MS X FC 901	SP 641204H01	4	5924	21.20	13.97	2.0	159
FC (502/2 X 504) MS X FC 901	SP 641204H03	5	5812	19.97	14.55	2.5	155
SP 5822-0; LSR check	Acc. 2623	6	3977	14.82	13.42	2.1	162
US H6; CTR check	Acc. 2633	7	5306	19.74	13.44	3.3	165
HH 9 (L. 4454); local check		8	5806	22.57	12.86	2.8	155
General mean			5341	19.59	13.63		
S.E. of var. mean			257[b/]	0.738	0.41		
S.E. of var. mean as % of gen. mean			4.81	3.77	2.98		
L.S.D. (.05)			729	2.10			

Variance Table

Source of variation	D/F	Mean squares (variance): Root yield	Mean squares (variance): Sucrose %
Variety	7	41.462	2.20
Rows	7	25.579	2.73
Error	49	4.362	1.32
Total	63		
Calculated F value		9.50**	1.66 NS

a/ Leafspot scale: 1 to 10 with 1 being high.

b/ Short cut formula.

NS Not significant.

** Exceeds 1% level 3.02.

Table 23(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Ft. Collins, Colo., 1965 (Exp. no. 1A).

Conducted by: J. A. Elder and J. O. Gaskill

Location: Hospital Farm, Fort Collins, Colorado; Field no. 2.

Cooperation: Colorado Agricultural Experiment Station, Beet Sugar Development Foundation, and National Sugar Manufacturing Company.

Dates of Planting and Harvest: April 29; October 19.

Experimental Design: Latin Square, 9 x 9; plots 2 rows x 20'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in a 17' section of each plot (34' of row) were hand topped, washed, and weighed.

Determination of Sucrose and Purity Percentages: All roots harvested in each plot were divided into 2 samples for sucrose and purity analyses. Two sucrose and one purity determination were made for the composited pulp from each sample.

Stand and Bolter Counts: For stand, all plants in the area to be harvested in each plot were counted just before harvest. Bolter percentages were determined by counts (entire plots) in midseason, and seedstalks were cut off at that time.

Recent Cropping History: 1961, sugarbeet; 1962-64, barley.

Chemicals Applied for 1965 Crop: Treble superphosphate (approximately 130 lbs. P_2O_5 per acre) and ammonium nitrate (approximately 80 lbs. N per acre) were applied before plowing in August, 1964. Shell DD (about 41 gal. per acre) was applied after plowing in August, 1964, for control of the sugarbeet nematode.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Western Yellows and sugarbeet nematode, mild effects; other diseases and pests, negligible.

Soil and Seasonal Conditions: The 1965 crop season was cooler and wetter than usual, especially during the first half. Precipitation was quite heavy during June. Adequate soil moisture was provided artificially throughout the season as needed, principally by furrow irrigation. Inoculation (July 12) and subsequent frequent sprinkling were used to promote the development of leaf spot (*Cercospora beticola*).

Reliability of Test: Very good.

Table 23(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Fort Collins, Colo., 1965 (Exp. 1A, 9-plot averages).

Description	Ft. Collins seed no.	Entry no.	Acre Yield Gross Sucrose	Acre Yield Roots	Sucrose	Leaf spot[a/] 8/23	Leaf spot[a/] 9/1	[b/] Vigor 8/9	Plants per 100'	Bolters	Thin juice purity
			Lbs.	Tons	%				No.	%	%
SL (129 X 133) MS X SP 5822-0	Acc. 2634	1	4186	13.08	15.99	3.9	4.3	6.3	124	0.47	94.0
CT 5 MS X SP 5822-0	Acc. 2635	2	4061	12.89	15.76	4.3	4.9	6.3	121	0.00	94.2
SL (129 X 133) MS X SP 6322-0	Acc. 2636	3	4492	13.97	16.07	3.7	4.3	6.4	123	0.00	94.0
FC (502/2 X 503) MS X FC 901	SP 641204H01	4	4992	14.79	16.87	2.7	3.2	6.9	121	0.23	94.7
FC (502/2 X 504) MS X FC 901	SP 641204H03	5	4751	14.32	16.59	2.8	3.2	6.8	123	0.00	94.5
SP 5822-0; LSR check	Acc. 2623	6	3939	12.55	15.70	2.1	2.2	6.7	120	0.51	95.0
US H6; CTR check	Acc. 2633	7	3953	12.83	15.40	5.7	6.2	6.0	122	0.00	94.0
GW 674-56C; local check	Acc. 2168	8	4361	13.60	16.04	2.9	3.9	7.0	122	0.00	94.0
SL (126 X 128) MS X SP 5822-0; local check	Acc. 2642	9	3926	12.32	15.93	4.2	4.8	6.4	126	0.00	94.0
General mean			4296	13.37	16.04						94.3
S. E. of var. mean			76.56	0.2286	0.0774						0.69
S. E. of var. means as % of gen. mean			1.78	1.71	0.48						0.73
L.S.D. (.05)			217	0.65	0.22						2.0

Variance Table

Source of Variation	D/F	Mean Square (variance) Gross sucrose	Roots	Sucrose %	Purity %
Rows	8	213,341.1	2.4720	0.2374	5.43
Columns	8	265,907.0	1.9850	0.0824	2.12
Varieties	8	1,330,728.4	6.4193	1.8168	1.29
Error (remainder)	56	52,756.4	0.4702	0.0539	4.28
Total	80				
Calculated F value		25.22**	13.65**	33.71**	0.30

a/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation.

b/ Foliage vigor: Larger number = greater vigor.

** F exceeds the 1% point.

Table 24(a)--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Rocky Ford, Colorado, 1965.

Conducted by: American Crystal Sugar Company.

Location: Rocky Ford, Colorado.

Dates of Planting and Harvest: April 13, October 6.

Experimental Design: Triple Lattice, repeated 3 times, 9 replications; plots 1 row x 35'; rows 22" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percent: Approximately one-half of the beets per plot were bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Recent Cropping History: Summer Fallow.

Fertilizer Applied to Sugar Beet Crop: 800 pounds of 18-46-0.

Leaf Spot Exposure: Medium to light.

Curly Top Exposure: Slight.

Other Diseases and Pests: Some Rhizoctonia.

Soil and Seasonal Conditions: Good.

Reliability of Test: Fair.

Table 24(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Rocky Ford, Colorado, 1965 (9-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre Yield: Gross sucrose	Acre Yield: Roots	Sucrose	Leaf spot[a/]	Stand (roots per 35')
			Lbs.	Tons	%		No.
SL (129 x 133)MS x SP 5822-0	Acc. 2634	1	5472	19.35	14.14	1.3*	31.8
CT 5 MS x SP 5822-0	Acc. 2635	2	6760	24.30	13.91	1.9	34.2
SL (129 x 133)MS x SP 6322-0	Acc. 2636	3	6509	23.72	13.72	2.1	31.3
FC (502/2 x 503)MS x FC 901	SP 641204H01	4	6137	21.12	14.53	1.6	33.7
FC (502/2 x 504)MS x FC 901	SP 641204H03	5	5692	20.43	13.93	1.8	27.7
SP 5822-0; LSR check	Acc. 2623	6	6509	23.00	14.15	0.7*	33.8
US H6; CTR Check	Acc. 2633	7	4238	16.25	13.04	3.3	25.0
60-806-0 (Am #2 Mono); Local ck.		8	5139	19.38	13.26	3.1	30.8
54-406-0 (Am #2 Multi); Local ck.		9	5635	19.76	14.26	3.0*	32.3
General Mean			5781	20.81	13.89		31.2
L.S.D. (.05)			1299	4.56	.71		- -
F Value			- -	2.64**	3.98**		NS
C. V. %			23.79	23.18	5.39		22.60

Variance Table [b/]

Source of Variation	D/F	Mean square (variance): Roots(lbs.)	Sucrose %	No.Roots(35')
Replications	8	420.7800	1.2225	59.6250
Component (a)	12	204.0200	0.9466	59.9167
Component (b)	6	299.8433	0.3050	87.3333
Blocks	18	235.9611	0.7328	69.0556
Varieties	8	505.5963	2.0525	83.8750
Error	46	191.6893	0.5154	44.9348
Total	80	255.9503	0.7888	55.7250

b/ For gross sucrose, SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{mean lbs beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{mean \% sucrose})}}$$

* 3-plot averages (omitting plots with poor stand). All others 4-plot averages.

a/ Leaf spot readings (9/13/65; J. O. Gaskill): 0 = no leaf spot; 10 = complete defoliation.

Table 25(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1965.

Conducted by: Roy E. Gwin, Jr., G. E. Coupland, and Henry Wolfe.

Location: Tribune Branch Station, Kansas Agricultural Experiment Station, Tribune, Kansas.

Cooperation: Kansas Agricultural Experiment Station and the National Sugar Manufacturing Co.

Date of Planting and Harvest: April 20; October 23, 1965.

Experimental Design: Latin Square, 9 X 9; plots 6 rows X 30'; rows 22" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in 50' of row in each plot were topped, cleaned, and weighed.

Determination of Sucrose Percentage: All roots harvested for root yield in each plot were divided into 3 or more samples for sucrose analysis.

Stand Counts: Based on harvested roots.

Leaf Spot Exposure: Mild and late.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: Ulysses Silt Loam; previous crop wheat; adequate irrigation; season was cool and about average in rainfall, except excessive rainfall at harvest.

Fertilization: Eighty pounds of actual nitrogen applied pre-plant as anhydrous ammonia.

Reliability of Test: The test is considered satisfactory on the whole. However, there were a few small areas in which extreme yellowing of foliage and low yields occurred, and exceptionally high yields were recorded for one plot. The average yields shown for entry no. 4 were affected substantially by a single plot in which the acre yield of roots was more than 8 tons below that of the other 8 plots of that variety. Conversely, the outstanding average yields shown for entry no. 2 were due in part to a single plot in which the acre yield of roots exceeded the average of the other 8 plots of that variety by more than 8 tons.

Table 25(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1965 (9-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield: Gross sucrose	Acre yield: Roots	Sucrose	Stand (beets per 100')
			Lbs.	Tons	%	No.
SL (129 X 133) MS X SP 5822-0	Acc. 2634	1	7205	23.71	15.15	165
CT 5 MS X SP 5822-0	Acc. 2635	2	8120	26.46	15.32	157
SL (129 X 133) MS X SP 6322-0	Acc. 2636	3	7664	25.12	15.24	143
FC (502/2 X 503) MS X FC 901	SP 641204H01	4	7430	23.76	15.59	153
FC (502/2 X 504) MS X FC 901	SP 641204H03	5	7825	25.34	15.42	154
SP 5822-0; LSR check	Acc. 2623	6	7127	23.14	15.38	152
US H6; CTR check	Acc. 2633	7	7616	25.65	14.82	144
SL (126 X 128) MS X SP 5822-0		8	7613	24.51	15.54	148
G.W.S. Co. monogerm var.		9	7653	23.77	16.11	154
General mean			7583.78	24.6073	15.3968	
S. E. of var. mean			302.57	0.8304	0.1924	
S. E. of var. mean as % of gen. mean			3.99	3.37	1.25	
L.S.D. (5% point)			857.	2.35	0.55	

Variance Table

Source of Variation	D/F	Mean Square (variance): Gross Sucrose	Roots	Sucrose %
Rows	8	3,810,617.9	37.2736	0.5733
Columns	8	1,561,899.5	12.9618	0.6289
Varieties	8	826,142.3	10.9297	1.1256
Error (remainder)	56	823,961.5	6.2054	0.3332
Total	80			
Calculated F value		1.00	1.76	3.38**

Table 26(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Garden City, Kansas, 1965.

Conducted By: American Crystal Sugar Company.

Location: Garden City, Kansas.

Dates of Planting and Harvest: April 23; November 5 & 6.

Experimental Design: Triple Lattice, 3 replications; plots 1 row x 35'; rows 24" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Approximately one-half of the beets per plot bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Light.

Curly Top Exposure: Light.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Satisfactory.

Reliability of Test: Too few replications.

Table 26(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Garden City, Kansas, 1965 (3-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre Yield: Gross sucrose	Acre Yield: Roots	Sucrose	Stand (roots per 35')
			Lbs.	Tons	%	No.
SL (129 x 133)MS x SP 5822-0	Acc. 2634	1	7046	25.53	13.80	51.7
CT 5 MS x SP 5822-0	Acc. 2635	2	7740	27.12	14.27	51.3
SL (129 x 133)MS x SP 6322-0	Acc. 2636	3	7223	23.87	15.13	52.3
FC (502/2 x FC 503)MS x FC 901	SP 641204H01	4	6203	21.20	14.63	59.7
FC (502/2 x FC 504)MS x FC 901	SP 641204H03	5	7016	22.99	15.26	50.7
SP 5822-0; LSR Check	Acc. 2623	6	6516	22.58	14.43	55.0
US H6; CTR Check	Acc. 2633	7	7059	24.46	14.43	55.3
60-806-0 (Am #2 Mono) local check		8	6783	22.61	15.00	48.3
54-406-0 (Am #2 Multi) local check		9	6577	22.07	14.90	50.3
General Mean			6924	23.60	14.67	52.7
L.S.D. (.05)			--	--	--	--
F. Value			--	NS	NS	NS
C. V. %			13.73	12.89	4.74	14.35

Variance Table [a]

Source of Variation	D/F	Mean Squares (variance): Roots (lbs.)	Sucrose %	No. Roots (35')
Replicates	2	72.0650	3.0050	98.5000
Component (b)	6	31.5117	1.5133	19.0000
Varieties	8	106.1038	1.0913	34.7500
Error	10	133.0870	0.3790	80.1000
Total	26	96.6500	1.0619	53.4615

a/ For gross sucrose SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\left(\frac{\text{SE lbs. beets}}{\text{Mean lbs. beets}}\right)^2 + \left(\frac{\text{SE \% sucrose}}{\text{Mean \% sucrose}}\right)^2}$$

Table 27(a)--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Johnson, Kansas, 1965.

Conducted By: American Crystal Sugar Company.

Location: Johnson, Kansas.

Dates of Planting and Harvest: April 14; November 4.

Experimental Design: Triple Lattice, 3 replications, plots 1 row x 35'; rows 24" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Approximately one-half of the beets per plot bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Very light.

Curly Top Exposure: Very light.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Satisfactory.

Reliability of Test: Too few replications.

Table 27(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Johnson, Kansas, 1965 (3-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre Yield: Gross sucrose	Acre Yield: Roots	Sucrose	Stand (roots per 35')
			Lbs.	Tons	%	No.
SL (129 x 133)MS x SP 5822-0	Acc. 2634	1	7272	25.66	14.17	45.3
CT 5 MS x SP 5822-0	Acc. 2635	2	7315	26.18	13.97	41.0
SL (129 x 133)MS x SP 6322-0	Acc. 2636	3	8737	29.78	14.67	45.0
FC (502/2 x FC 503)MS x FC 901	SP 641204H01	4	7638	27.28	14.00	48.3
FC (502/2 x FC 504)MS x FC 901	SP 641204H03	5	7430	25.62	14.50	43.7
SP 5822-0; LSR Check	Acc. 2623	6	6841	25.15	13.60	46.0
US H6; CTR Check	Acc. 2633	7	7252	25.59	14.17	47.7
60-806-0 (Am #2 Mono.); local check		8	6576	23.32	14.10	41.3
54-406-0 (Am #2 Multi); local check		9	6940	23.98	14.47	50.1
General Mean			7323	25.84	14.17	45.4
LSD (.05)			1326	---	---	---
F Value			--	NS	NS	NS
C. V. %			9.96	8.79	4.70	16.62

Variance Table a/

Source of Variation	D/F	Mean Squares (variance): Roots (lbs.)	Sucrose %	No. Roots (35')
Replicates	2	127.9600	2.4050	27.5000
Component (b)	6	73.3783	1.3150	54.5000
Varieties	8	109.1888	0.3350	27.8750
Error	10	47.0800	0.3480	58.4000
Total	26	78.4808	0.7254	45.7308

a/ For gross sucrose SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\left(\frac{\text{SE lbs. beets}}{\text{Mean lbs. beets}}\right)^2 + \left(\frac{\text{SE \% sucrose}}{\text{Mean \% sucrose}}\right)^2}$$

Table 28(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Goodwell, Oklahoma, 1965.

Conducted By: R. Norton Ford and Roy Oswalt.

Location: Panhandle Agricultural Experiment Station, Goodwell, Oklahoma.

Cooperation: Oklahoma Agricultural Experiment Station, Holly Sugar Corp., Great Western Sugar Company, American Crystal Sugar Company, U.S.D.A. Fort Collins, Colorado.

Dates of Seeding and Harvest: April 3; October 30.

Experimental Design: Randomized block; 10 replications; plots 3 rows x 21', rows 28" apart, center row test variety, 2 rows common border US-35/2; hand thinned to single plants 7" apart.

Determination of Root Yield: All roots in 16' of harvested row were hand topped, cleaned and weighed.

Determination of Sucrose Percentages: A random sample of roots was taken from the row and shipped to Holly Sugar Corporation for analysis.

Recent Cropping History: 1964 castorbeans.

Chemicals Applied for Sugar Beet Crop: 100 lbs. of N (applied as ammonium nitrate) applied on April 1 broadcast.

Leaf Spot Exposure: Moderate.

Curly Top Exposure: Moderate.

Other Diseases and Pests: Mild to negligible.

Soil and Seasonal Conditions: June 1965 was the 5th wettest on record (54 years). Above normal humidity during May and June. The soil was not pre-irrigated. Severe moisture stress was prevented throughout the growing season by furrow irrigation.

Reliability of Test: Good.

Table 28(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Goodwell, Oklahoma, 1965 (10-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre Yield: Gross Sucrose	Acre Yield: Roots	Sucrose	Leaf spot [a/]
			Lbs.	Tons	%	
SL (129 x 133)MS x SP 5822-0	Acc. 2634	1	7725	28.6	13.5*	1.9
CT 5 MS x SP 5822-0	Acc. 2635	2	8204	32.8	12.4	1.6
SL (129 x 133)MS x SP 6322-0	Acc. 2636	3	7947	30.5	13.0	2.0
FC (502/2 x 503)MS x FC 901	SP 641204H01	4	8192	30.7	13.3	1.4
FC (502/2 x 504)MS x FC 901	SP 641204H03	5	8834	32.3	13.6*	1.2
SP 5822-0; LSR check	Acc. 2623	6	7819	27.2	14.3*	1.2
US H6; CTR check	Acc. 2633	7	6803	29.0	11.7	3.5
61-4T28-H11 (triploid hybrid) (Am.Cry.Su.Co.)			7457	30.2	12.3	2.1
62-401-0 (American Crystal Sugar Company)			8169	30.8	13.2	2.7
62-GH #2-1 (American Crystal Sugar Company)			8554	29.3	14.6*	2.5
62 MSH200 (Great Western Sugar Company)			10222*	35.9*	14.2*	2.3
GWH2-64A (Great Western Sugar Company)			9114	32.5	14.0	2.1
HH10 (Holly Sugar Corporation)			9919*	36.3*	13.6*	2.4
General Mean			8379	31.2	13.4	
*LSD at .05 level of significance			1015	2.5	1.2	
CV =			13.65%	8.9%	10.2%	

Variance Table

Source of Variation	D/F	Mean Square (variance) and Calculated F Values: Gross sucrose	F	Roots	F	Sucrose percent	F
Replications	9	7.71	7.95	236.93	10.19	3.22	1.70
Treatments (entries)	12	6.62	6.82*	211.40	9.09*	7.29	3.90*
Error (remainder)	108	0.97	- --	23.26	- --	1.87	- --
Total	129	- --	- --	-- --	- --	- --	- --

a/ Leaf spot readings (9/16/65; J. O. Gaskill): 0 = no leaf spot; 10 = complete defoliation.

Table 29(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Hereford, Texas, 1965.

<u>Conducted by</u>: D. F. Peterson and Paul Scott.

<u>Location</u>: Hereford, Texas; Eddie Reinauer farm.

<u>Cooperation</u>: Holly Sugar Corporation.

<u>Dates of Planting and Harvest</u>: March 25; October 18.

<u>Experimental Design</u>: Latin Square, 9 X 9; plots 2 rows X 54'; rows 30" apart.

<u>Determination of Root Yield</u>: All roots in a 50' section of each plot were weighed.

<u>Determination of Sucrose Percentage</u>: Two 10-beet samples per plot.

<u>Leaf Spot Exposure</u>: Moderately severe.

<u>Curly Top Exposure</u>: Moderately severe.

<u>Other Diseases and Pests</u>: Negligible.

<u>Remarks</u>: High fertility, good stands, and good uniformity in agronomic practices combined to make this a highly reliable test.

Table 29(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Hereford, Texas, 1965 (9-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield: Gross sucrose	Acre yield: Roots	Sucrose	Plants per 100'
			Lbs.	Tons	%	No.
SL (129 X 133) MS X SP 5822-0	Acc. 2634	1	5847	18.99	15.40	177
CT 5 MS X SP 5822-0	Acc. 2635	2	6744	21.85	15.43	180
SL(129 X 133) MS X SP 6322-0	Acc. 2636	3	6433	20.66	15.57	179
FC (502/2 X 503) MS X FC 901	SP 641204H01	4	5615	17.81	15.76	174
FC (502/2 X 504) MS X FC 901	SP 641204H03	5	6497	20.93	15.52	183
SP 5822-0; LSR check	Acc. 2623	6	4152	13.58	15.29	156
US H6; CTR check	Acc. 2633	7	5904	19.80	14.91	171
HH 10; local check		8	5995	19.90	15.06	182
HH 12; local check		9	5223	17.26	15.13	175
General Mean			5823	18.98	15.34	175
S. E. of var. mean			134 a/	0.414	0.11	
S. E. of var. mean as % of gen. mean			2.30	2.18	0.72	
L.S.D. (.05)			380	1.18	0.31	

Variance Table

Source of variation	D/F	Mean square (variance): Root yield	Mean square (variance): Sucrose %
Rows	8	11.42	0.06
Columns	8	6.99	0.24
Varieties	8	56.15	0.65
Error (remainder)	56	1.54	0.11
Total	80		
Calc. F value		36.44**	5.97**

a/ S. E. of var. mean calculated by formula.

** Exceeds 1% point of significance (2.88)

Table 30(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Artesia, New Mexico, 1965.

Conducted by: W. J. Russell

Location: Southeastern Branch Station, New Mexico Agricultural Experiment Station, Artesia, New Mexico.

Cooperation: New Mexico Agricultural Experiment Station.

Dates of Planting and Harvest: March 10; October 13.*

Experimental Design: Balanced lattice design (K+1 replications); two double row beds per plot, beds 40 inches apart; rows 22 feet long. Analyzed as a randomized complete block.

Determination of Root Yield: Twenty feet of two rows per plot.

Determination of Sucrose Percentage: All roots harvested for root yield from inside 20 feet of two rows per plot. The pulp was frozen and sent to Holly Sugar Corporation for laboratory analysis; hand refractometer readings were made prior to freezing the pulp for comparison with laboratory analysis.

Stand Counts: Harvested beets counted when weighed. Diseased roots were counted in stand but were not included in yield.

Recent Cropping History: Winter barley 1964; Fallow 1963; Forage sorghum 1962.

Fertilizers applied for 1965 Crop: Broadcast 95 pounds nitrogen and 87 pounds P_2O_5 per acre prior to bed preparation.

Leaf Spot Exposure: Moderately severe after September 1.

Curly Top Exposure: Extremely severe.

Other Diseases and Pests: Root rot and root aphids.

Soil and Seasonal Conditions: Preplant application of Tillam was broadcast and incorporated into soil by double disking. Plots were not cultivated but were hoed when necessary. Irrigated 16 times with a total of 58 acre inches of water.

Remarks: Early infestations of leafhopper caused stunted growth in the curly top susceptible check variety, SP 5822-0.

* Note: An additional harvest job was performed on November 13, but sucrose data, if any, are not available for this report. Consequently, results of the later harvest have been largely omitted in the accompanying table.--Ed.

Table 30(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Artesia, N. M., 1965 (4-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield: Gross sucr. 10/13	Acre yield: Roots 10/13	Sucrose 10/13	Refractometer 10/13	Refractometer 11/13	Leaf spot[a/] 9/2	Leaf spot[a/] 11/12	Curly top[b/] 9/2	Plants per lin. ft. 10/13	Dis. roots[c/] 10/13
			Lbs.	Tons	%	%	%				No.	%
SL (129 X 133) MS X SP 5822-0	Acc. 2634	1	5136	21.40	12.0	14.75	17.85	1.8	2.8	4	2.32	3.53
CT 5 MS X SP 5822-0	Acc. 2635	2	4881	19.68	12.4	15.50	18.20	3.0	4.2	4	2.54	4.34
SL (129 X 133) MS X SP 6322-0	Acc. 2636	3	4778	21.72	11.0	13.58	18.25	1.0	1.8	3	2.31	4.78
FC (502/2 X 503) MS X FC 901	SP 641204H01	4	5002	19.85	12.6	16.15	18.92	0.9	1.2	4	2.02	0.26
FC (502/2 X 504) MS X FC 901	SP 641204H03	5	5416	22.38	12.1	15.00	17.90	0.2	1.4	4	1.80	1.56
SP 5822-0; LSR check	Acc. 2623	6	2510	8.90	14.1	17.65	20.55	0.2	1.0	9	1.61	27.98
US H6; CTR check	Acc. 2633	7	5032	28.59	8.8	10.85	13.50	0.4	1.0	1	2.53	1.61
HH 10; local check		8	6566	24.50	13.4	17.02	19.85	3.0	3.2	5	2.50	1.70
Holly 3227-05; local check		9	6880	25.48	13.5	16.90	20.05	1.4	2.0	5	2.40	0.00
General mean			5133	21.39	12.2	15.27	18.34	1.3	2.1	4	2.45	5.08
L.S.D. (.05)				4.89	1.5	2.02	1.81			1.4	0.50	
L.S.D. (.01)				6.63	2.1	2.74	2.46			1.9	0.68	
C.V.%				15.68	8.6	9.09	6.77			21.6	15.38	

Variance Table

Source of variation	D/F	Mean square (variance): Root yield	Sucrose %	Refract. 10/13	Refract. 11/13	Curly top	Plants per ft.
Replicates	3	22.57	1.63	1.09	1.64	1.11	0.71**
Varieties	8	120.28**	9.97**	17.49**	17.16**	17.42**	0.45**
Error	24	11.24	1.11	1.92	1.55	0.92	0.12
Total	35						

a/ Leaf spot: 0 = healthy; 10 = all tops dead.

b/ Curly top: 0 = healthy; 9 = all tops dead.

c/ Yield does not include diseased roots.

* Significant at the .05 level. ** Significant at the .01 level.

Table 31(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Moorhead, Minnesota, 1965.

Conducted By: American Crystal Sugar Company.

Location: Moorhead, Minnesota.

Dates of Planting and Harvest: May 19; October 5.

Experimental Design: Triple Lattice, repeated three times, 9 replications; plots 1 row x 35'; rows 22" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Approximately one-half of the beets per plot were bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Light.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Good.

Reliability of Test: Fair.

Table 31(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Moorhead, Minnesota, 1965 (9-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre Yield: Gross sucrose	Acre Yield: Roots	Sucrose	Stand (roots per 35')
			Lbs.	Tons	%	No.
SL (129 x 133)MS x SP 5822-0	Acc. 2634	1	4167	13.78	15.12	29.1
CT 5 MS x SP 5822-0	Acc. 2635	2	4284	14.66	14.61	30.0
SL (129 x 133)MS x SP 6322-0	Acc. 2636	3	4691	15.43	15.20	29.6
FC (502/2 x 503)MS x FC 901	SP 641204H01	4	4373	13.76	15.89	28.6
FC (502/2 x 504)MS x FC 901	SP 641204H03	5	4644	15.07	15.41	31.6
SP 5822-0; LSR check	Acc. 2623	6	4020	13.88	14.48	24.1
US H6; CTR check	Acc. 2633	7	4981	16.67	14.94	28.7
60-806-0 (Am #3 S); Mono.; local check		8	4522	14.55	15.54	30.3
Am #3 N (Multi) local check		9	3902	13.42	14.54	25.9
General Mean			4397	14.58	15.08	28.6
L.S.D. (.05)			641	- --	.60	4.2
F Value			---	NS	5.37**	2.68**
C. V. %			15.42	14.84	4.19	15.62

Variance Table a/

Source of Variation	D/F	Mean Squares (variance): Roots (lbs.)	Sucrose %	No. Roots (35')
Replicates	8	46.7750	1.1875	23.3750
Component (a)	12	24.9133	0.5350	24.7500
Component (b)	6	24.3900	0.1733	39.1666
Blocks	18	24.7389	0.4144	29.5556
Varieties	8	82.8000	2.1212	47.6250
Error	46	46.9483	0.3954	17.7609
Total	80	45.5190	0.6514	23.9625

a/ For gross sucrose SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs.beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

Table 32(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Mason City, Iowa, 1965.

Conducted By: American Crystal Sugar Company.

Location: Mason City, Iowa.

Dates of Planting and Harvest: May 5; October 14.

Experimental Design: Triple Lattice, repeated 3 times, 9 replications; plots 1 row x 35'; rows 22" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Approximately one-half of the beets per plot were bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Light.

Curly Top Exposure: None.

Other Diseases and Pests: Some Rhizoctonia.

Soil and Seasonal Conditions: Extremely dry at midseason, causing severe wilting. Extremely wet at harvest time, over 11 inches of rain in September. Soil very sandy.

Reliability of Test: Fair to poor.

Table 32(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Mason City, Iowa, 1965 (9-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre Yield: Gross sucrose	Acre Yield: Roots	Sucrose	Leaf spot a/	Stand (roots per 35')
			Lbs.	Tons	%		No.
SL (129 x 133)MS x SP 5822-0	Acc. 2634	1	2095	9.26	11.31	5.0	34.4
CT 5 MS x SP 5822-0	Acc. 2635	2	2230	9.63	11.58	4.5	31.7
SL (129 x 133)MS x SP 6322-0	Acc. 2636	3	2097	8.90	11.78	3.5	32.4
FC (502/2 x 503)MS x FC 901	SP 641204H01	4	2030	8.78	11.56	2.0	33.6
FC (502/2 x 504)MS x FC 901	SP 641204H03	5	2356	9.64	12.20	2.0	34.4
SP 5822-0; LSR check	Acc. 2623	6	1986	8.62	11.52	2.5	31.3
US H6; CTR check	Acc. 2633	7	2638	12.26	10.76	3.5	38.7
60-806-0 (Am #3S Mono.)local ck.		8	1976	8.38	11.79	3.5	31.3
Am #3S (Multi.) local ck.		9	2295	10.48	10.95	3.0	33.8
General Mean			2194	9.55	11.49		33.5
L.S.D. (.05)			512	2.14	.78		---
F Value			---	2.53**	2.58*		NS
C. V. %			24.80	23.74	7.18		22.05

Variance Table b/

Source of Variation	D/F	Mean Squares (variance): Roots (lbs.)	Sucrose %	No. Roots (35')
Replicates	8	767.8686	59.9625	233.7500
Component (a)	12	47.2583	0.1658	99.8333
Component (b)	6	40.0250	1.0900	71.8333
Blocks	18	44.8472	0.4739	90.5000
Varieties	8	112.9363	1.7575	47.6250
Error	46	44.5846	0.7609	47.3913
Total	80	123.8073	67.1613	75.7500

b/ For gross sucrose SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\left(\frac{\text{SE lbs. beets}}{\text{Mean lbs. beets}}\right)^2 + \left(\frac{\text{SE \% sucrose}}{\text{Mean \% sucrose}}\right)^2}$$

a/ Leaf spot readings (D. E. Farus) 0 = no leaf spot; 5 = complete defoliation. (Ratings were made in Leaf Spot Nursery, average of 2 replications; not in field.)

Table 33 .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Beltsville, Md., 1965 (3-plot averages).a/

Description	Ft. Collins seed no.	Entry no.	Acre yield: Gross sucr.	Acre yield: Roots	Sucrose	Leaf spot b/: 8/6	Leaf spot b/: 8/12	Leaf spot b/: 9/4	Vig.: 6/25	Plants per 100'
			Lbs.	Tons	%					No.
SL (129 X 133) MS X SP 5822-0	Acc. 2634	1	4680	18.82	12.40	3.3	3.5	4.6	3.2	88
CT 5 MS X SP 5822-0	Acc. 2635	2	3531	15.41	11.50	4.0	4.0	4.6	3.1	69
SL (129 X 133) MS X SP 6322-0	Acc. 2636	3	4998	20.76	12.05	3.3	3.4	4.6	3.3	77
FC (502/2 X 503) MS X FC 901	SP 641204H01	4	4570	18.55	12.32	3.1	3.1	4.4	3.2	82
FC (502/2 X 504) MS X FC 901	SP 641204H03	5	5115	21.57	11.87	2.8	3.1	4.2	3.0	80
SP 5822-0; LSR check	Acc. 2623	6	4925	19.98	12.33	2.6	2.8	3.9	3.1	78
US H6; CTR check	Acc. 2633	7	3184	15.20	10.47	4.3	4.5	5.3	2.8	87
SP 64100-05; mm, local check		8	3658	17.16	10.68	3.6	3.7	5.2	3.1	88
SP 6322-0; observational ck.						2.0	2.3	3.2	3.2	83
General mean			4333	18.43	11.70					
S. E. of var. mean			304.69	1.3614	0.1627					
S. E. of var. mean as % of gen. mean			7.03	7.39	1.39					
L.S.D. (.05)			924	4.13	0.49					

Variance Table

Source of variation	D/F	Mean square (variance): Gross sucr.	Roots	Sucrose %
Replications	2	169,019.0	2.1580	0.2283
Varieties	7	1,714,820.4	16.7412	1.7213
Error (remainder)	14	278,533.2	5.5607	0.0794
Total	23			
Calc. F value		6.16**	3.01*	21.68**

a/ Test conducted by G. E. Coe, U. S. Dept. of Agr.; randomized-block design; plots 4 rows by 20'; rows 24" apart; harvest results and stand based on the 2 inner rows (full length) in each plot.

b/ Severe leaf spot exposure developed artificially. Basis of grades: 0 = no leaf spot; 10 = complete defoliation.

* Exceeds 5% point. ** Exceeds 1% point.

Fig. 1.--Comparison of sugarbeet varieties under severe curly top exposure, Artesia, N. M., September 17, 1965; plots 4 rows (2 beds) wide and 22 ft. long. Left, SP 5822-0; right, FC (502/2 x 503) MS x FC 901. (Fort Collins photo no. 180-18).

P A R T IX

RHIZOCTONIA INVESTIGATIONS

Utilization of Inoculation Techniques and Selecting for Resistance

J. O. Gaskill

Cooperation: Colorado State University

The research was supported in part by funds provided through the Beet Sugar Development Foundation (Project 25).

RHIZOCTONIA INVESTIGATIONS, FORT COLLINS, COLORADO, 1965 [1/]

(A phase of Beet Sugar Development Foundation Project 25)

John O. Gaskill [2/]

The efficacy of several inoculation techniques for evaluation of the Rhizoctonia resistance of sugarbeet lines was studied at Fort Collins during the period, 1956 through 1964. As reported at the end of that period (2) [3/], the rosette method, previously described (1, 3), appears to be the most dependable where inoculation is performed at least three weeks after thinning. That technique was used exclusively in 1965, and an attempt was made to determine whether the 3-week interval between thinning and inoculation is long enough--in other words, whether resistance could be measured more effectively if the plants were larger at the time of inoculation. In a separate experiment a number of sugarbeet lines, resulting from one to several generations of selection for Rhizoctonia resistance, were compared with parental and check material. Selection and breeding for resistance were continued in 1965.

Experiment R-1

(Methods Study)

The same set of sugarbeet varieties or strains used in the methods study in 1964 was employed in 1965. For convenience in appraising the results, the varieties and seed numbers used in 1965 are listed below:

Strain no.	Ft. Collins seed no.	Description
1	Acc. 2233	SP 5831-0; a monogerm, U.S.D.A. variety, resistant to leaf spot and black root.
2	SP 621004-0	A product of selection for Rhizoctonia resistance, at Ft. Collins, in SP 5831-0.

[1/] A progress report on investigations conducted by the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation.

[2/] Research Plant Pathologist.

[3/] Numbers in parentheses refer to Literature Cited.

3	Acc. 2168	GW 674-56C; a multigerm, G.W.S. Co., leaf spot resistant variety.
4	SP 631001-0	A product of selection for Rhizoctonia resistance, at Ft. Collins, in GW 674-56C (via SP 611107-0).
5	SP 62122uH0	An increase of C817 (Powers' Select A54-1 Synthetic) without selection for Rhizoctonia resistance.
6	SP 621003-0	A product of selection for Rhizoctonia resistance, at Ft. Collins, in C817.
7	Acc. 2057	US 401; a multigerm, U.S.D.A. variety, resistant to leaf spot and black root.
8	Acc. 2591	SP 5822-0; a multigerm, U.S.D.A. variety, resistant to leaf spot and black root.

A randomized-block, split-plot, experimental design was used with dates of planting occurring as main plots and sugarbeet strains as subplots. Each subplot was two rows wide and 25 feet long. A 14-ft. section of each subplot was inoculated by means of the rosette method on July 26, using the highly pathogenic Rhizoctonia isolate, B-6. Planting dates were May 19 and June 3, and thinning was performed on June 23 and July 6, respectively. Thus, elapsed time from thinning to inoculation was about five weeks for the early planting and three weeks for the late planting. Final determinations of stand and yield were made on a 13-ft. section (26 feet of row) in the inoculated portion of each subplot on October 8. Plants with living foliage were counted, trimmed as mother beets, washed and weighed. Irrigation water was applied to the entire experiment by sprinkler in amounts considered sufficient for satisfactory plant growth. The east half (three replications) received supplemental sprinkling beginning soon after the date of inoculation. For further details regarding agronomic practices, inoculation technique, etc., see the 1963 report (1).

The results of experiment R-1 are summarized in Tables 1 and 2 and illustrated in Figure 1. As shown in Table 1, loss of stand was much more severe in the late planting. However, as shown in both tables, varietal contrasts were considerable for both planting dates and tended to be relatively greater for the later planting. Thus, under the conditions of 1965, it appears that the late planting was somewhat more effective in showing strain differences. However, conditions in the 1965 experiment apparently were less favorable for Rhizoctonia than usual, presumably due to cooler weather, and consequently these results should be considered with caution.

Table 1.--Comparative survival percentages [a/] of sugarbeet strains, under Rhizoctonia exposure, as influenced by soil moisture and by age of plants at time of inoculation, Ft. Collins, Colo., 1965 (Exp. R-1); basic results presented as 3-plot averages; determinations made at harvest (October 8).

Strain no.	High moisture [b/]			Low moisture			Aver., high and low moisture			Aver. as % of parent
	Early [c/]	Late [c/]	Aver.	Early [c/]	Late [c/]	Aver.	Early [c/]	Late [c/]	Aver.	
1	56.6	36.8	46.7	73.8	44.0	58.9	65.2	40.4	52.8	-----
2	57.2	42.0	49.6	82.6	43.3	63.0	69.9	42.6	56.3	106.6
3	45.4	30.1	37.8	64.5	17.8	41.2	55.0	24.0	39.5	-----
4	80.4	46.4	63.4	79.1	56.9	68.0	79.8	51.7	65.7	166.3
5	75.3	22.0	48.6	77.7	22.2	50.0	76.5	22.1	49.3	-----
6	89.8	72.7	81.3	92.7	79.8	86.3	91.3	76.3	83.8	170.0
7	43.3	19.5	31.4	58.6	36.7	47.6	50.9	28.1	39.5	-----
8	40.2	24.2	32.2	51.4	28.6	40.0	45.8	26.4	36.1	-----
Aver.	61.0	36.7	48.9	72.6	41.2	56.9	66.8	38.9	52.9	-----
LSD (.05)									9.4	
F (dates)									68.65	
F (strains)									22.86**	
F (strains x dates)									3.16**	

a/ Stand (living plants) at harvest expressed as % of stand at time of inoculation (July 26).

b/ The high moisture condition was begun on August 9.

c/ Early and late refer to time of planting (early, May 19; late, June 3).

** F exceeds the 1% point.

Table 2.--Comparative root yields of sugarbeet strains, under Rhizoctonia exposure, as influenced by soil moisture and by age of plants at time of inoculation, Ft. Collins, Colo., 1965 (Exp. R-1); basic results presented as 3-plot averages; determinations made at harvest (October 8). [a/]

Strain no.	High moisture [b/] Early [c/]	Late [c/]	Aver.	Low moisture Early [c/]	Late [c/]	Aver.	Aver., high and low moisture Early [c/]	Late [c/]	Aver.	Aver. as % of parent
1	12.97	7.90	10.43	17.80	9.10	13.45	15.38	8.50	11.94	----
2	14.21	7.59	10.90	20.24	8.43	14.33	17.22	8.01	12.62	105.70
3	15.10	6.40	10.75	18.90	3.33	11.12	17.00	4.87	10.93	----
4	25.38	12.21	18.79	24.84	15.13	19.98	25.11	13.67	19.39	177.40
5	22.13	5.13	13.63	23.77	4.87	14.32	22.95	5.00	13.98	----
6	29.21	15.08	22.15	31.34	22.25	26.80	30.28	18.67	24.47	175.04
7	12.43	5.20	8.82	15.33	9.03	12.18	13.88	7.12	10.50	----
8	8.97	4.43	6.70	10.60	6.20	8.40	9.78	5.32	7.55	----
Aver.	17.55	7.99	12.77	20.35	9.79	15.07	18.95	8.89	13.92	
LSD (.05)									2.61	
F (dates)									62.65**	
F (strains)									34.58**	
F (strains x dates)									5.14**	

a/ Results expressed as pounds of roots per plot (26' of row).

b/ The high moisture condition was begun on August 9.

c/ Early and late refer to time of planting (Early, May 19; late, June 3). Inoculation was performed on July 26.

** F exceeds the 1% point.

Strain comparisons of special interest are parents vs. products of selection for Rhizoctonia resistance. Strain 2 differed very little from its parental variety, strain 1. However, strains 4 and 6 exceeded their respective parents by highly significant amounts, both in percentage survival and in root yield. Moisture levels had relatively little effect.

Experiment R-2

(Comparison of Strains)

Experiment R-2 was intended primarily for the evaluation of the Rhizoctonia resistance of a number of lines resulting from selection for resistance to that disease. Plots were one row by 25 feet in size. A 14-ft. section in each plot was inoculated, and final determinations of stand and yield were based on a 13-ft. section in each plot. Strains with sufficient seed occurred in eight plots, each, with a modified randomized-block arrangement. Five strains occurred in two to six plots each. Except for these modifications, Experiment R-2 was handled in about the same way and on essentially the same schedule as the early planting of Experiment R-1. Inoculation was performed by means of the rosette method July 26-27, and harvest was performed October 8-11.

As shown in Table 3, strains differed greatly in survival percentage and root yield, and a number of the selections were far superior to the three commercial varieties in the test--GW 674-56C, US 401, and SP 5822-0 (entries 914, 929, and 930, respectively). As in the methods study (Experiment R-1), selections from SP 5831-0 differed very little from that variety, and SP 631001-0 was significantly higher than its parent, GW 674-56C, in both survival and yield. In the methods study strain no. 6, the selection from C817, was the outstanding line in both survival and yield. In Experiment R-2, the next generation of that line--SP 641005-(01)-- was highest in survival and second from the top in yield, disregarding those lines that occurred in less than eight plots.

The performance of SP 641004-(02) is of special interest and may indicate the achievement of a new level of Rhizoctonia resistance. As stated above, SP 631001-0, resulting from two cycles of selection from GW 674-56C, significantly exceeded that variety both in survival and yield. SP 641004-(02), a product of three selection cycles from the same source, in turn surpassed SP 631001-0 by highly significant amounts in both survival and yield. Furthermore, in root yield, SP 641004-(02) significantly exceeded all other lines occurring in eight replications. The appearance of that line just prior to harvest is shown in Figure 2.

Table 3.--Comparison of sugarbeet strains for Rhizoctonia resistance, at and just prior to harvest, Ft. Collins, Colo., 1965; Exp. R-2.

Description	Seed no.	Entry no.	No. of plots	Survival [a/] 10/8-11	Root yield [b/] 10/8-11	Rhizoc. grade [c/] 10/7
				%	Lbs.	
SP 5831-0; LSR-BRR, mm, syn. var.	Acc. 2233	911	8	63.6	8.25	5.8
Sel. for Rhizoc. res. from SP 5831-0 (SP 611104-0, SP 621004-0)	SP 641003-(01)	912	8	69.9	8.93	4.9
do.	SP 641003-(02)	913	4	64.9	7.65	6.0
GW-674-56C; LSR, MM, com'l. var.	Acc. 2168	914	8	51.4	8.06	7.3
Sel. for Rhizoc. res. from GW-674-56C (SP 611107-0)	SP 631001-0	931	8	71.4	12.14	5.5
Sel. for Rhizoc. res. from GW-674-56C (SP 611107-0, SP 621113-00)	SP 641004-(01)	915	8	82.0	13.08	4.5
do.	SP 641004-(02)	916	8	92.8	17.04	2.5
do. (SP 631102-3 or -4)	SP 641004-(3)	917	2	107.6	14.65	5.0
Incr. of G.W.S. Co. C817 (Powers' Sel. A54-1 Syn.) w/o sel. for Rhizoc. res.; LSR, MM	SP 621220H0	918	8	81.3	12.76	5.9
Sel. for Rhizoc. res. from C817 [SP 611105-(02), SP 621003-0]	SP 641005-(01)	919	8	97.1	14.03	3.6
Sel. for Rhizoc. res. from the G.W.S. Co. line, XGR 62108-3; MM	SP 641100-1	920	8	77.6	10.17	3.8
Sel. for Rhizoc. res. from misc. source material	SP 641223-1	921	8	91.4	13.18	4.5
do.	SP 641223-2	922	4	90.7	13.26	4.3
do.	SP 641223-3	923	8	64.4	12.84	5.9
do.	SP 641223-4	924	4	81.2	14.38	4.5
Sel. for Rhizoc. res., largely from SP 611100-0 (LSR-CTR, mm, prob. seg. for T.O.) (SP 621233-01A and -02A)	SP 641001-0	925	8	27.7	3.18	8.3
Sel. for Rhizoc. res. from SP 611227-(001) (LSR-CTR, mm, prob. seg. for T.O.)	SP 641002-0	926	8	61.1	7.44	6.0
Sel. for Rhizoc. res. from the F_2 of SLC 127 x SP 581813-00; LSR-CTR, seg. for m and prob. for T.O.	SP 641222-(01)	927	8	74.7	6.00	6.4
Sel. for Rhizoc. res. from the F_2 of SL 7213 x SP 581813-00; LSR-CTR, prob. seg. for m and T.O.	SP 641222-(2)	928	6	74.8	9.44	4.5
US 401; LSR-BRR, MM	Acc. 2057	929	8	58.7	7.80	7.5
SP 5822-0; LSR-BRR, MM	Acc. 2591	930	8	46.7	4.60	7.5
General mean (entries occurring in 8 plots)				69.5	9.97	---
LSD (.05) (entries occurring in 8 plots)				16.1	2.70	---
LSD (.01) (entries occurring in 8 plots)				21.3	3.57	---
F (strains) (entries occurring in 8 plots)				10.15**	15.57**	---

a/ Stand (living plants) at harvest, expressed as % of stand at time of inoculation (July 26-27).

b/ Roots of living plants per plot (13 ft. of row)

c/ Visual pre-harvest estimate of Rhizoctonia injury based on depression of both stand and vigor: 0 = healthy; 10 = complete loss (all plants dead).

** F value exceeds the 1% point.

Conclusions

1. The results from two experiments in 1965 confirmed earlier conclusions that progress had been made in breeding for resistance to Rhizoctonia.

2. SP 641004-(02), a line resulting from three cycles of selection for Rhizoctonia resistance, was outstanding in root yield under Rhizoctonia exposure and may represent the achievement of a new level of resistance.

3. Where the rosette method of inoculation was used with intervals of approximately three and five weeks between thinning and inoculation, Rhizoctonia attack was more severe on the younger plants--i.e., on those plants having only about three weeks' growth between dates of thinning and inoculation. Under 1965 conditions, this greater severity of attack on the younger plants resulted in relatively greater contrasts among sugarbeet strains. However, in seasons more favorable for Rhizoctonia, a lighter level of attack, expected to result from a longer interval between thinning and inoculation, may be desirable.

Literature Cited

(1) Gaskill, John O. Rhizoctonia investigations, Fort Collins, Colorado, 1963. Sugarbeet Research, 1963 Report (CR-4-64, Crops Research Division, A.R.S., U.S.D.A.): 350-357.

(2) Gaskill, John O. Rhizoctonia Investigations, Fort Collins, Colorado, 1964. Sugarbeet Research, 1964 Report. (In press).

(3) Pierson, Victor G., and John O. Gaskill. 1961. Artificial exposure of sugar beets to Rhizoctonia solani. J. Am. Soc. Sugar Beet Technol. 11(7): 574-590.

Figure 1.--Comparison of three sugarbeet strains in Experiment R-1, Ft. Collins, Colo., on October 6, 1965, 72 days after inoculation with Rhizoctonia solani. Two-row plots, from left to right: 1) strain 8 (SP 5822-0); 2) strain 6 (SP 621003-0, a Rhizoctonia-resistant selection from C817); and 3) strain 3 (GW 674-56C). (Ft. Collins photo B28-14.)

Figure 2.--Comparison of four sugarbeet strains in Experiment R-2 (1-row plots), Ft. Collins, Colo., on October 6, 1965, 71 days after inoculation with Rhizoctonia solani. The first three staked plots, from left to right, are SP 641004-(02), SP 641003-(01), and SP 641005-(01)--products of selection for Rhizoctonia resistance in GW 674-56C, SP 5831-0, and C817, respectively. The fourth plot is the commercial variety GW 674-56C. (Ft. Collins photo B28-9.)

Fig. 1.--Comparison of three sugarbeet strains in Experiment R-1, Ft. Collins, Colo. (See page 238 for legend.)

Fig. 2.--Comparison of four sugarbeet strains in Experiment R-2 (1-row plots), Ft. Collins, Colo. (See page 238 for legend.)

PART X

ASSOCIATION OF 3-HYDROXYTYRAMINE WITH ROOT WEIGHT AND SUCROSE PERCENTAGE[1/]

- - -

SAMPLING FOR PHENOLIC COMPOUNDS ASSOCIATED WITH LEAF SPOT RESISTANCE[1/]

- - -

FAILURE TO TRANSMIT CYTOPLASMIC MALE STERILITY BY GRAFTING[1/]

- - -

COMPUTER CALCULATION OF THIN JUICE PURITY

- - -

POPULATION GENETICS AND BREEDING METHODS[1/]

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Cooperation: Colorado State University

1/ The research was supported in part by funds provided through the Beet Sugar Development Foundation (Project 25).

PROGRESS REPORT TO THE BEET SUGAR DEVELOPMENT FOUNDATION ON THE GENETIC, PLANT BREEDING, AND BIOCHEMICAL PHASES OF PROJECT NUMBER 25

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The genetic, plant breeding, and biochemical phases of Project 25 are cooperative with the Beet Sugar Development Foundation, the Agronomy and Chemistry Departments of the Colorado State Agricultural Experiment Station, and the Colorado State University Department of Mathematics and Statistics.

Contributions of the late Dr. LeRoy Powers to this report are acknowledged. In large part the experimental designs are his as well as certain of the analyses and results.

Acknowledgement is due the Western Data Processing Center at the University of California at Los Angeles for use of computing facilities in analysis of certain portions of these data; job number 1081.

Literature citations for the first four report sections are on page 282; citations for the remainder are on page 328.

Chemical-Genetic Studies Involving Weight per Root, Percentage Sucrose, and Levels of 3-hydroxytyramine [1/]

The data for levels of 3-hydroxytyramine from individual plants were not available in time to include them in the 1964 annual report. Hence they are being included in the 1965 report. The purposes of this experiment were to study the association of 3-hydroxytyramine with weight per root and percentage sucrose and to determine the breeding potentials of the segregating populations A56-3 and US 401(4N) as regards levels of 3-hydroxytyramine. The hybrid, (52-305CMS X 52-407)F_1, was included as a measure of the environmental variability. The methods outlined by Powers et al. (8) were used in analyzing the data. The experimental design was a randomized complete block having 40 replications and nine populations. However, individual plant data were taken on only three of the nine populations. The number of plants per replication was ten, making a total of 400 plants for each population and a total of 1200 plants for the three populations. The plot data for the nine populations were given in the 1964 annual report.

Results

The analyses of variance for weight per root in kgs, percentage sucrose, and mg of 3-hydroxytyramine per 100 ml of extract are shown in Table 1. For weight per root there are significant differences between means of populations but not between means of replications. Such being the case, the interaction of populations X replications is not significant. For percentage sucrose, differences between means of populations, means of replications, and the interaction of populations X replications are statistically significant. The same sources of variation are significant in the 3-hydroxytyramine analysis. It should be noted that although the differences between replication means for percentage sucrose and mg of 3-hydroxytyramine are statistically significant, as compared with differences between population means, they account for a relatively small amount of the variance. The comparisons are 0.218456 and 0.021972 for percentage sucrose and 34.701170 and 0.910031 for mg of 3-hydroxytyramine. The variances for the population X replication interaction are still smaller and hence of minor importance as compared with differences attributable to populations.

The means and frequency distributions for weight per root on the arithmetic scale are listed in Table 2. The means and frequency distributions of A56-3 and US 401 (4N) are not different. The least significant difference of their means is 0.072. Chi square for testing the hypothesis that both populations are derived from a common frequency distribution is 13.047 with 12 degrees of freedom. The P value lies between 0.50 and 0.30. The deviations are readily accounted for by chance.

The means and frequency distributions for percentage sucrose on the arithmetic scale are listed in Table 3. There are significant

1/ For association with Cercospora leaf spot resistance, see page 255.

Table 1. Analysis of variance for weight per root, percentage sucrose, and mg of 3-hydroxytyramine; logarithmic scale.

Character and source of variation	Degrees of freedom	Mean square	F value Obtained	5.0%	1.0%
Weight per root					
Populations	2	0.227334	3.35	3.11	4.88
Replications	39	0.057768	----	1.54	1.84
R X P[1/]	78	0.067921	----	1.28	1.41
Remainder[1/]	1080	0.071080			
Percentage sucrose					
Populations	2	0.218456	39.33	3.11	4.88
Replications	39	0.021972	3.96	1.54	1.84
R X P[1/]	78	0.005555	3.04	1.28	1.41
Remainder[1/]	1080	0.001826			
3-hydroxytyramine					
Populations	2	34.701170	135.83	3.11	4.88
Replications	39	0.910031	3.56	1.54	1.84
R X P[1/]	78	0.255474	2.31	1.28	1.41
Remainder[1/]	1080	0.110613			

[1/] The R X P mean square is used to test significance of differences between means of populations and means of replications; the remainder mean square is used to test the significance of the interaction, replications X populations.

Table 2. Population frequency distributions for kilograms per root; arithmetic scale.

Population	Upper class limits in kilograms																		Mean
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	
A56-3	8	32	48	42	54	53	41	31	29	19	15	8	9	5	3	1	2		1.17
US 401(4N)	22	42	44	43	40	45	41	41	27	17	12	7	7	2	3	6	0	1	1.13
(52-305CMS X 52-407)F_1	7	17	29	85	99	72	48	25	14	3	1								0.97

$LSD_{0.05} = 0.072$
$LSD_{0.01} = 0.094$

Table 3. Population frequency distributions for percentage sucrose; arithmetic scale.

Population	Upper class limit, expressed in percent																							Mean
	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	
A56-3	1	3	2	7	5	5	11	16	36	30	40	46	57	46	36	20	21	10	5	2	0	0	1	15.4
US 401(4N)	11	3	8	9	10	12	15	32	30	41	45	46	48	42	19	16	8	4	1					14.6
(52-305CMS X 52-407)F_1				1	0	1	2	4	14	19	43	53	51	59	52	50	18	17	10	3	1	0	2	16.1

$LSD_{0.05} = 0.34$
$LSD_{0.01} = 0.45$

differences between all three means. The same is true of the frequency distributions. The means and frequency distributions for mg of 3-hydroxytyramine in Table 4 are all significantly different.

Total within-plot variances, genetic variances, and heritability ratios for weight per root, percentage sucrose, and mg of 3-hydroxytyramine are listed in Table 5. A study of this table reveals that for weight per root and percentage sucrose the genetic variances and therefore the broad sense heritability ratios are larger for population US 401(4N) than they are for A56-3. The reverse is true for mg of 3-hydroxytyramine. In past studies population A56-3 compared with other populations has usually been found to have greater genetic variability for both weight per root and percentage sucrose. Consequently the greater variability for weight per root and percentage sucrose shown by the tetraploid was not expected. This finding raises the question whether the greater genetic variability of US 401(4N) could be due in part to the fact that it is a tetraploid. The experiment was not designed to give an answer to this question. Further research is necessary involving 2N and 4N conditions of the same populations.

All possible combinations of within-plot total and genetic correlations are listed in Table 6. The F_1 hybrid provides an estimate of the environmental correlations. The environmental correlation of weight per root and percentage sucrose is -0.403, that of weight per root and mg of 3-hydroxytyramine is 0.423, and finally that of percentage sucrose and mg of 3-hydroxytyramine is -0.191. All three of these correlation coefficients are significantly different from zero and together with the genetic correlations will have a bearing on breeding procedures. A study of Table 6 reveals that for population A56-3 the genetic correlation coefficients for weight per root and percentage sucrose and for percentage sucrose and mg of 3-hydroxytyramine are positive and significantly different from zero. In population US 401(4N) the genetic correlation coefficients for weight per root and percentage sucrose and weight per root and mg of 3-hydroxytyramine are positive and significantly different from zero. Both the environmental and genetic relations noted between the three characters have a bearing on breeding procedures. Just what this bearing is, and its nature, is more clearly shown by partitioning the bivariate frequency distributions so as to obtain an estimate of the identifiable numbers of genetic deviates.

In Table 7 are listed the number of individuals in each of the nine sections of the partitioned bivariate frequency distributions for weight per root and percentage sucrose. The number of individuals falling in sections 4, 5, and 6 are of greatest interest because they have the greatest potential for increasing both weight per root and percentage sucrose. The number of individuals falling in section 5 is of greatest importance because these individuals are superior in both weight and sucrose; whereas those in section 4 are superior in weight but average in sucrose, and those in section 6 are average in weight but superior in sucrose. A further study of Table 7 reveals that the identifiable

Table 4. Population frequency distributions for mg of 3-hydroxytyramine; arithmetic scale.

Population	Upper class limit, expressed as milligrams																							Mean
	0.5	1.8	3.1	4.4	5.7	7.0	8.3	9.6	10.9	12.2	13.5	14.8	16.1	17.4	18.7	20.0	21.3	22.6	23.9	25.2	26.5	27.8	29.1	
A56-3	10	45	76	60	50	35	22	12	15	7	11	10	15	3	7	6	3	5	0	6	1	1		6.64
US 401(4N)	6	36	53	59	46	38	25	29	22	9	8	8	6	2	4	10	9	3	9	12	5	1		7.96
(52-305CMS X 52-407)F_1		2	2	7	12	12	19	17	22	12	17	16	15	19	11	10	21	23	42	67	27	16	2	17.76

$LSD_{0.05} = 1.31$

$LSD_{0.01} = 1.72$

Table 5. Within-plot total and genetic variances, and heritability ratios for weight per root, percentage sucrose, and mg of 3-hydroxytyramine; logarithmic scale.

Character and population	Variance		Heritability ratio	F value			
	Total	Genetic		Obtained Total	Obtained Genetic	5%	1%
Weight per root							
A56-3	0.074960	0.040712	0.543	1.39	1.71	1.16	1.24
US 401(4N)	0.104033	0.069785	0.671				
(52-305CMS X 52-407)F_1	0.034248	--------	-----				
Percentage sucrose							
A56-3	0.001676	0.000959	0.572	1.84	2.47	1.16	1.24
US 401(4N)	0.003085	0.002368	0.768				
(52-305CMS X 52-407)F_1	0.000717	--------	-----				
3-hydroxytyramine							
A56-3	0.164123	0.129926	0.792	1.23	1.31	1.16	1.24
US 401(4N)	0.133520	0.099323	0.744				
(52-305CMS X 52-407)F_1	0.034197	--------	-----				

Table 6. Within-plot correlation coefficients for weight per root and percentage sucrose, weight per root and mg of 3-hydroxytyramine, and percentage sucrose and mg of 3-hydroxytyramine, calculated within populations for total and genetic covariances; logarithmic scale.

Source of variation and population	Correlation coefficient, r		
	Weight and sucrose	Weight and 3-hydroxy-tyramine	Sucrose and 3-hydroxy-tyramine
Total within-plot			
A56-3	-0.080	0.183**	0.037
US 401(4N)	0.206**	0.210**	0.022
(52-305CMS X 52-407)F_1	-0.403**	0.423**	-0.191**
Genetic			
A56-3	0.175**	0.080	0.140*
US 401(4N)	0.442**	0.124*	0.091

Table 7. Number of individuals in sections of the partitioned bivariate frequency distributions for weight per root and percentage sucrose; logarithmic scale.

Population	Section descriptions[1/] and numbers								
	Inf. wt., inf. suc. (1)	Ave. wt., inf. suc. (2)	Sup. wt., inf. suc. (3)	Sup. wt., ave. suc. (4)	Sup. wt., sup., suc. (5)	Ave. wt., sup., suc. (6)	Inf. wt., sup., suc. (7)	Inf. wt., ave. suc. (8)	Ave. wt., ave., suc. (9)
	No.	No.	No.	No.	No.	No.	No.	No.	No.
A56-3	14	25	25	55	35	65	38	54	89
US 401(4N)	32	14	23	64	60	58	40	38	71
(52-305CMS X 52-407)F_1	3	19	14	58	3	73	27	28	175

1/ Inf. = Inferior
wt. = weight per root
Ave. = Average
Sup. = Superior
suc. = sucrose

numbers of genetic deviates in both sections 4 and 6 are negligible. However, for section 5 the identifiable number of genetic deviates is high for both A56-3 and US 401(4N), the identifiable number of genetic deviates being 32 in the former case and 57 in the latter case. US 401(4N) is significantly higher in identifiable number of genetic deviates in section 5 than is A56-3. Since the number of individuals in sections 4 and 6 for the F_1 hybrid approximate rather closely those in these sections for A56-3 and US 401(4N), progress would not be expected by saving for breeding purposes individuals falling in these sections. Hence the data show that selection of individuals from section 5 for further breeding studies in populations A56-3 and US 401(4N) should offer promise of progress. To identify the superior lines would require progeny tests of some type.

In Table 8 are listed the number of individuals in each of the nine sections of the partitioned bivariate frequency distributions for weight per root and mg of 3-hydroxytyramine. A study of these data reveals that the greatest number of superior genetic deviates occurs in sections 5 and 6 of the bivariate frequency distributions (assuming high 3-hydroxytyramine is desirable). Section 5 is superior in both weight per root and mg of 3-hydroxytyramine whereas section 6 is average in weight and superior in mg of 3-hydroxytyramine. Neither segregating population is superior to the other in the identifiable number of genetic deviates in these two sections; the numbers are 53 for A56-3 and 51 for US 401(4N). If numbers greater than these are desired for selection and further testing, size of the populations studied would have to be increased correspondingly.

In Table 9 are listed the number of individuals in each of the nine sections of the partitioned bivariate frequency distributions for percentage sucrose and mg of 3-hydroxytyramine. Again the greatest number of superior genetic deviates occurs in sections 5 and 6. The two populations do not differ significantly in respect to identifiable numbers of genetic deviates in these two sections; but section 5 does contain a higher proportion of the identifiable number of genetic deviates than section 6. The individuals of section 5 are superior in both characters, whereas the individuals of section 6 have average sucrose but are superior in mg of 3-hydroxytyramine. Selection of individuals in section 4 would be of doubtful value due to the fact that the number of individuals of the segregating populations falling in this section does not differ materially from the number of F_1 hybrid individuals falling in this same section.

Discussion

Individual plant determinations allow us to partition the variances, covariances, and frequency distributions, thereby providing much information not available on population or variety means. This experiment provides the first data on 3-hydroxytyramine from individual plants.

Table 8. Number of individuals in sections of the partitioned bivariate frequency distributions for weight per root, mg of 3-hydroxytyramine; logarithmic scale.

Population	Section descriptions[1/] and numbers								
	Inf. wt., inf. 3-hyd. (1)	Ave. wt., inf. 3-hyd. (2)	Sup. wt., inf. 3-hyd. (3)	Sup. wt., ave. 3-hyd. (4)	Sup. wt., sup. 3-hyd. (5)	Ave. wt., sup. 3-hyd. (6)	Inf. wt., sup. 3-hyd. (7)	Inf. wt., ave. 3-hyd. (8)	Ave. wt., ave. 3-hyd. (9)
	No.	No.	No.	No.	No.	No.	No.	No.	No.
A56-3	57	76	38	38	39	37	22	27	66
US 401(4N)	57	67	51	53	43	31	17	36	45
(52-305CMS X 52-407)F_1	34	87	10	51	14	9	1	23	171

1/ Inf. = Inferior
wt. = weight per root
Ave. = average
Sup. = Superior
3-hyd. = 3-hydroxytyramine

Table 9. Number of individuals in sections of the partitioned bivariate frequency distributions for percentage sucrose and mg of 3-hydroxytyramine; logarithmic scale.

Population	Section descriptions[1/] and numbers								
	Inf. suc., inf. 3-hyd. (1)	Ave. suc., inf. 3-hyd. (2)	Sup. suc., inf. 3-hyd. (3)	Sup. suc., ave. 3-hyd. (4)	Sup. suc., sup. 3-hyd. (5)	Ave. suc., sup. 3-hyd. (6)	Inf. suc., sup. 3-hyd. (7)	Inf. suc., ave. 3-hyd. (8)	Ave. suc., ave. 3-hyd. (9)
	No.	No.	No.	No.	No.	No.	No.	No.	No.
A56-3	27	93	51	46	41	42	15	22	63
US 401(4N)	37	77	61	60	37	41	13	19	55
(52-305CMS X 52-407)F_1	5	81	45	54	4	15	5	26	165

1/ Inf. = Inferior
suc. = sucrose
Ave. = Average
Sup. = Superior
3-hyd. = 3-hydroxytyramine

Variation due to populations is the principal source of variability for all three characters in all three populations. Environmental effects as measured by replications affect sucrose and 3-hydroxytyramine content in this experiment, the latter being affected four times as much as the former. These variances are small, however, compared to population variances. The data for the variances were transformed to common logarithms in order to reduce the apparent relationships of means and variances.

Further work is planned to study 3-hydroxytyramine content in a range of environments, e.g., different soil fertility levels, and in a variety of genotypes. This should help in pinning down particular environmental factors affecting 3-hydroxytyramine as well as delineating the extent to which the character may be affected by environment.

The population means and variances for 3-hydroxytyramine are of particular interest. The mean of the F_1 hybrid is particularly high as was pointed out in the 1964 report. This F_1 hybrid is of particular interest for this reason and will be included in future experiments to study this currently inexplicably high 3-hydroxytyramine content. The within-plot variance of this F_1 hybrid serves as an estimate of the environmental variance. This being the case there must be considerable segregation and/or interaction of genes conditioning 3-hydroxytyramine content in the two segregating populations. The resulting broad sense heritability ratios are quite high. This would indicate that decisive genetic shifts should be possible in breeding for this character. But since we do not know what types of gene action are involved it is not possible to say which breeding methods should be most effective. Further studies are planned to provide this information.

The correlation coefficients are within population correlations calculated using replication means. The positive total correlation of weight and sucrose in US 401(4N) and the absence of a significant correlation in A56-3 is not surprising since there is often an insufficient genetic range in a particular variety to estimate the correlation for sugarbeets in general. The positive genetic correlations are also not unusual within varieties. Based on the nine populations in this study, it was reported in 1964 that these correlations were negative except for sucrose with 3-hydroxytyramine. These correlations based on nine populations are likely to provide a better estimate of the correlation in sugarbeets. So it appears that within any one variety it is possible to have correlations different than those across varieties. In any case the genetic correlations in Table 6 do not appear high enough to rule out breeding for any combination of the three characters.

Before the bivariate frequency distributions were partitioned the univariate distributions were adjusted to remove population and replication effects. The resulting distributions had a common mean and could be compared directly without assuming normality. Hence it is a nonparametric or distribution free method.

The identifiable numbers of genetic deviates indicate little difference in the two populations so far as breeding potential is concerned. Among the three combinations of characters these data indicate that superior weight and sucrose would be the most difficult to achieve. Simultaneous improvement of weight and 3-hydroxytyramine or sucrose and 3-hydroxytyramine should be more readily achieved. This observation is particularly true in A56-3.

Leaf spot resistance scores for the three populations were not made in this study. In the 1964 report A56-3 and US 401(4N) were classified as resistant. Based on observations of the F_1 hybrid in 1965 it is considered to be moderately resistant. This fact introduces some new problems into the relationship of 3-hydroxytyramine to leaf spot resistance. The high 3-hydroxytyramine content of this F_1 hybrid is an exception to the otherwise positive relation of 3-hydroxytyramine content and leaf spot resistance in the 1964 report. Does this mean that total 3-hydroxytyramine content may not be as important as the relative quantity of its oxidizing enzyme or its capacity to synthesize 3-hydroxytyramine in response to a stimulus? The quantity and relation of its oxidizing enzyme polyphenoloxidase (7) is currently being studied.

Summary

Individual plant data (400 plants per population) on weight, sucrose and 3-hydroxytyramine are presented for three populations. Variation in all three characters is primarily due to population differences. The 3-hydroxytyramine content of the F_1 hybrid is inexplicably high considering its leaf spot resistance. This introduces some new questions about the relationship of 3-hydroxytyramine content and level of Cercospora leaf spot resistance.

High genetic variances for 3-hydroxytyramine indicate that its content could be shifted through breeding. But this study is not designed to provide information about the types of gene action controlling 3-hydroxytyramine content; hence the most efficient breeding methods cannot be proposed. Data from the partitioned frequency distributions indicate that simultaneously improved weight and 3-hydroxytyramine or sucrose and 3-hydroxytyramine should be more easily achieved than improved weight and sucrose. Further studies are planned on the effect of environment and genotype on 3-hydroxytyramine content as well as its relationship with its oxidizing enzyme, leaf spot resistance, weight, sucrose, and certain quality characters.

Sampling for Phenolic Compounds[1/]

Interest has been generated for further research on the phenolic compounds since Harrison et al. (7) published their article which described the association of a certain phenolic compound with resistance to Cercospora leaf spot. This phenolic compound was later isolated and identified as 3-hydroxytyramine by Dr. Gardner.[2/] When this compound was oxidized, it was found to be highly toxic to Cercospora beticola growing in pure culture. There is a naturally occurring polyphenoloxidase enzyme in the leaf that is capable of oxidizing the 3-hydroxytyramine. (Genetic studies, p.242.)

Both of these compounds are currently being studied. However, preliminary results indicated that data for both characters were quite variable even when samples were taken from uniform populations. Therefore, work was initiated to determine the stage of growth at which the beet should be sampled, what part of the leaf should be sampled, etc. The purpose of this report is to describe some of the results obtained from these studies.

One study was undertaken to determine the concentration of 3-hydroxytyramine and polyphenoloxidase present at four stages of growth in each of ten populations which were known to differ in resistance to Cercospora leaf spot. These data give information showing how the compounds build up in the leaves and indicate which is the most desirable stage to be sampled.

The four growth stages when the leaves were sampled are as follows:

(1) Taken as soon as a sufficient sample for analysis could be obtained after thinning, June 15, 1964.

(2) Taken when the leaves were about one-half fully expanded, July 13, 1964.

(3) Taken when the leaves were fully expanded. July 30, 1964.

(4) Taken from older leaves, August 5, 1964.

These samples were immediately quick frozen and stored until removed for analysis which was conducted by Mrs. Maag.

1/ The research reported here was conducted in cooperation with Merle G. Payne, Professor of Chemistry, Colorado State University.

2/ Gardner, R. L. 1964. Identification of a compound from Beta vulgaris reported to be responsbile for resistance to Cercospora leaf-spot. Unpublished PH.D. Dissertation. Colorado State University.

The analysis of variance for concentration of 3-hydroxytyramine and polyphenoloxidase analyzed at various stages of growth is listed in Table 1. The analyses indicate that the concentrations of 3-hydroxytyramine and polyphenoloxidase activity certainly differ when analyzed at these stages. There is also a stage X population interaction which suggests that some populations have a higher concentration of 3-hydroxytyramine at one stage and other populations have a higher concentration at another stage. The F values due to population variations are highly significant which means there are significant differences in the concentrations of the phenolic compounds among populations.

Table 1. Variance analysis of concentrations of 3-hydroxytramine and polyphenoloxidase analyzed from leaf samples taken at four growth stages.

Source of variation	Degrees of freedom	3-hydroxytyramine		Polyphenoloxidase	
		MS	F	MS	F
Total	159				
Replication	3	191.5128	1.1434	0.0154	2.2319
Stage	3	15,512.7033	92.6134 **	9.5587	138.5319**
Population	9	3,690.0512	22.0302 **	0.0535	7.7536**
S X P	27	871.3069	5.2018 **	0.0109	1.5797
Error	117	167.4995		0.0069	

** Denotes significance at 1% level

When looking at the concentration of 3-hydroxytyramine in Table 2, it may be noted, from the mean of all populations at each stage, that stages one and four do not differ significantly nor do stages two and three; however, stages one and four have a lower concentration than do stages two and three. The concentration apparently builds up in the leaves as they grow and decreases after the leaves are fully expanded (see figure 1), perhaps as a result of oxidation or translocation. Entries 1, 4, 6, 8, 9, and 10 tend to have a higher concentration in stage two while entries 2, 3, 5, and 7 seem to be higher in stage three. Therefore, either stage two or three would be the best time to analyze for 3-hydroxytyramine because the concentrations are the highest then.

The concentration of polyphenoloxidase apparently builds up in the leaves as they grow, much as the 3-hydroxytyramine does, but it does not decrease in older leaves. There is less polyphenoloxidase present at the first

Table 2. Means for mg/100ml of 3-hydroxytyramine and optical density reading for polyphenoloxidase at each of four stages of growth.

Population	Entry number	3-hydroxytyramine Growth stages				Polyphenoloxidase Growth stages			
		1	2	3	4	1	2	3	4
A56-3	1	3.68	41.38	22.00	9.88	0.24	0.91	1.30	1.25
(52-305CMS X 52-408)F_1	2	6.52	57.75	59.88	12.75	0.24	0.95	1.40	1.29
SP 5481-0 (2n)	3	2.00	15.50	27.00	9.00	0.32	0.86	1.32	1.32
SP 5481-0 (4n)	4	1.75	20.75	20.50	10.62	0.26	0.90	1.34	1.32
US 201	5	2.22	41.75	43.38	14.00	0.25	0.99	1.31	1.39
(52-305CMS X 52-407)F_1	6	9.12	122.75	99.00	21.62	0.19	0.67	1.16	1.16
SP 5822-0	7	2.42	20.50	28.38	7.38	0.24	0.96	1.34	1.29
GW 777-60A	8	2.80	34.75	27.50	10.38	0.28	1.05	1.34	1.26
AC 62-4T22 (4n)	9	2.98	48.00	43.75	17.38	0.34	1.03	1.26	1.34
HH 10	10	2.80	28.00	24.75	8.25	0.31	0.95	1.37	1.31
LSD_{05}		3.01	15.85	32.22	5.55	0.04	0.19	0.09	0.10
LSD_{01}		4.07	21.44	43.50	7.49	0.05	----	0.12	----
Mean of each stage:		3.63	43.11	39.61	12.12	0.27	0.93	1.31	1.29
LSD_{05}		19.26				0.10			
LSD_{01}		25.55				0.14			

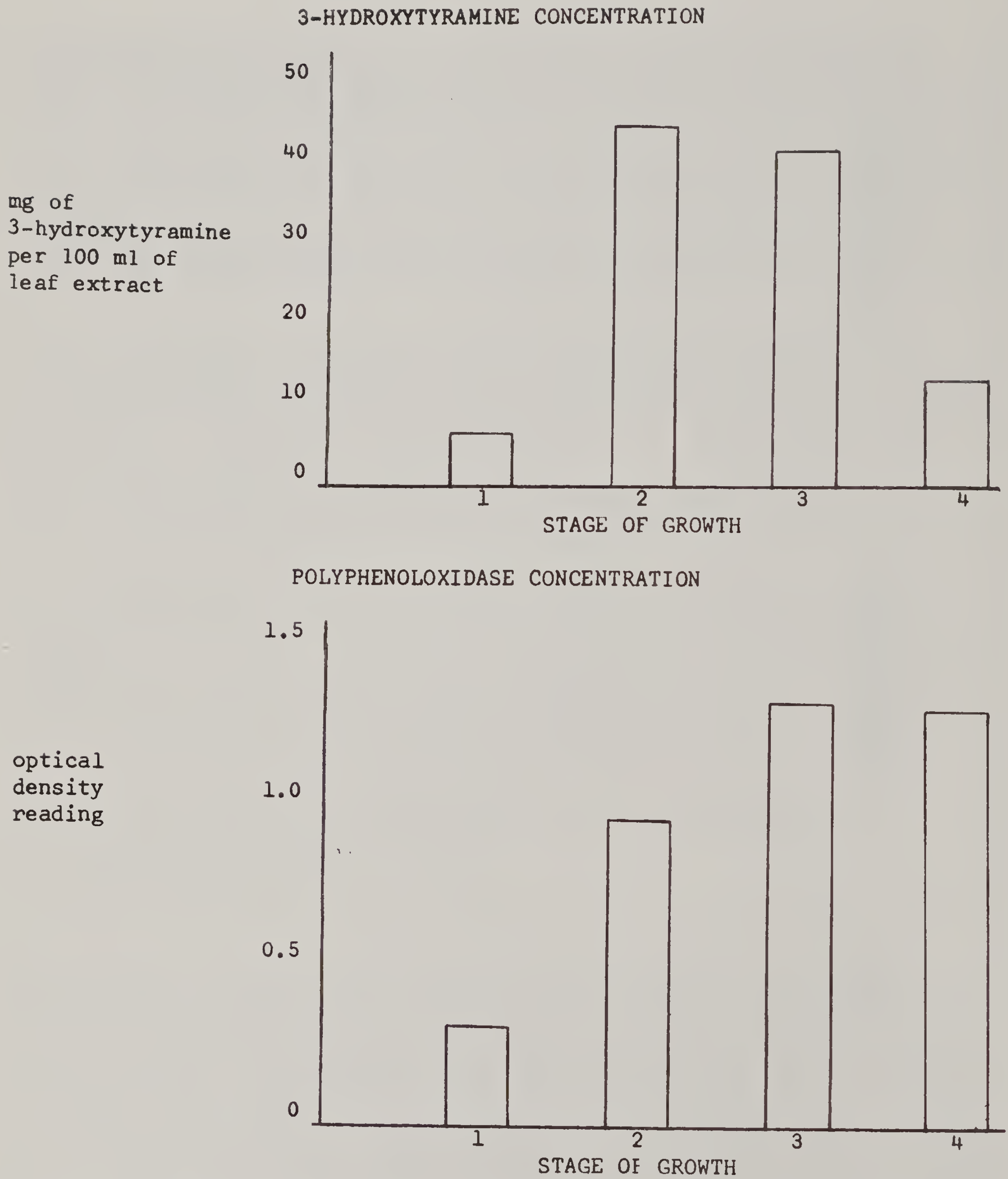

Figure 1. Concentration of 3-hydroxytyramine and polyphenoloxidase in sugarbeet leaves which were sampled at four growth stages. Stage 1, from young leaves after thinning; stage 2, from leaves that are one-half fully expanded; stage 3, from fully expanded leaves; stage 4, from older leaves.

stage than at the second stage and the second stage has less than either the third or fourth stages. Stages three and four do not differ significantly; hence the best time to obtain samples for polyphenoloxidase would probably be any time after the leaves are fully expanded.

Since analyses for both 3-hydroxytyramine and polyphenoloxidase can be obtained from the same sample, time and labor can be saved if the samples are taken at one stage. The third stage when the leaves are fully expanded is probably the most practical because this is the time when the highest concentrations of both phenolic compound and enzyme are attained in the leaves.

Not only is there a change in the concentration of 3-hydroxytyramine with respect to the growing season, but also a difference in various parts of the leaves and with different aged leaves.

When the leaves were divided laterally (into tip and basal halves) the bottom half of the leaves contained considerably larger amounts of 3-hydroxytyramine on a weight basis than the top half, but when the leaves were divided longitudinally down the mid-rib (vertically) the two halves contained nearly equal amounts of 3-hydroxytyramine on a weight basis. This was a consistent finding on leaves of different varieties and with different aged leaves. The petioles were much lower in 3-hydroxytyramine than the leaves and there was only a trace present in the roots. The most reliable way found of sampling leaves for 3-hydroxytyramine was to take a lateral section from the center of the leaves stacked one on top of another, discarding both the tip and the base of the leaves.

Of perhaps greater significance was the comparison of the concentration of 3-hydroxytyramine from different aged leaves of the same mature plant. If the first fully mature leaves (usually four) were taken, the 3-hydroxytyramine content was found to be nearly equal; but when several leaves were taken of different ages, the concentration of 3-hydroxytyramine varied over a wide range.

Samples were taken from individual plants. In one experiment four leaves of as nearly the same age as possible were collected from four plants. From four other plants leaves were collected starting with the oldest living leaf and working in toward the crown and young leaves. These results are presented in Table 3.

From Table 3 it is evident that the concentration of 3-hydroxytyramine decreases in the older leaves. It has been observed that Cercospora leaf spot attacks older leaves and only rarely do spots appear on young leaves--even in leaves of a susceptible variety. This is true for many leaf spotting diseases. Possibly the higher concentration of 3-hydroxytyramine may be related in some manner to the resistance of the young leaves to attacks of Cercospora beticola.

The information shown in Tables 2 and 3 appears conflicting; however, the data shown in Table 2 come from plants of different growth stages

Table 3. 3-hydroxytyramine content in leaves of same age.

Plant number	Weight of leaf		mg 3-hydroxytyramine per 100 ml extract*
1	16.0	mature leaf	5.0
	9.7	mature leaf	11.0
	12.0	mature leaf	6.5
	13.0	mature leaf	5.5
2	6.3	mature leaf	31.5
	10.0	mature leaf	17.0
	6.8	mature leaf	21.5
	7.0	mature leaf	21.5
3	8.9	mature leaf	18.0
	9.6	mature leaf	14.0
	10.7	mature leaf	13.5
	7.7	mature leaf	12.0
4	11.0	mature leaf	3.0
	8.8	mature leaf	4.5
	11.0	mature leaf	2.5
	11.2	mature leaf	2.0

3-hydroxytyramine content in leaves of varying ages

Plant number	Weight of leaf		mg 3-hydroxytyramine per 100 ml extract*
5	3.5	young leaf	25.0
	4.7	mature leaf	17.5
	15.5	old leaf	4.0
6	3.3	very young leaf	143.5
	5.2	young leaf	145.0
	12.0	mature leaf	37.0
	20.0	old leaf	8.0
7	3.7	very young leaf	90.5
	4.9	young leaf	56.5
	17.0	mature leaf	8.5
	34.0	old leaf	2.5
8	3.0	young leaf	99.5
	5.8	mature leaf	26.0
	18.0	old leaf	2.5

* this value is based on the weight of the leaf.

while the data shown in Table 3 are obtained from mature plants. Leaves from seedlings will contain less 3-hydroxytyramine than leaves from older plants while the younger leaves on that older plant will contain more 3-hydroxytyramine than its older leaves.

An attempt was made to determine the effect of injury upon the concentration of 3-hydroxytyramine in the leaves. Fresh leaves were placed in moist chambers for periods up to 24 hours. One vertical half of the leaf was used as a control and the other half as a treatment, but the leaves were kept intact until analysis.

When one-half of the leaf was injured by scratching with very fine emery cloth there was always an increase in 3-hydroxytyramine in the injured half of the leaf compared to the opposite half receiving no injury. Leaves were divided down the mid-rib for analysis. Injury by scratching and applying a solution of ground *Cercospora beticola* fungus may have increased the 3-hydroxytyramine more than scratching alone, but due to the unequal injury by scratching no conclusions could be drawn.

The amount of increase in 3-hydroxytyramine in injured tissue did not appear to have any relation to the amount of 3-hydroxytyramine in the uninjured portion of the leaf. This again may have been more due to variable injury than to any basic property of the leaves. However, it is possible that the resistance of a plant may depend more on its ability to synthesize 3-hydroxytyramine upon injury than any original concentration present.

These results may have significance when the biochemical nature of disease resistance is better understood.

1965 Phenolic Compound Study in a Series of S_1 Lines

This study was a continuation of research into the relationships of Cercospora leaf spot resistance with various plant characters including 3-hydroxytyramine which Harrison et al. (7) had identified as a phenolic compound. They also indicated that it was associated with leaf spot resistance. The characters studied were leaf spot resistance, root weight, percentage sucrose, percentage apparent purity, 3-hydroxytyramine, and polyphenoloxidase which is the enzyme capable of oxidizing 3-hydroxytyramine resulting in a substance toxic to the leaf spot organism. This was a joint study conducted by chemistry, genetics, and pathology in cooperation with M. Payne of the Chemistry Department, Colorado State University. J. O. Gaskill obtained disease readings from the plants grown in his leaf spot nursery,while M. Harrison and G. W. Maag determined concentrations of 3-hydroxytyramine and polyphenoloxidase in leaves from disease-free plants of the same populations grown on the Colorado State University Agronomy Research Center. Measurements of root weight, percentage sucrose, and percentage purity obtained by the genetics section were made on the same plots from which the chemical samples were determined. It was necessary to grow the plants on separate areas so that the characters other than leaf spot resistance could be determined on healthy plants. The relationships of these characters are sometimes different when they are obtained from diseased plants.

The study was based on selfed lines of A56-3 and A56-3, itself; this is an open-pollinated commercial variety adapted to the east slope of the mountains. Four hundred forty random roots of A56-3 were transplanted to the selfing plots in 1964; 180 of these plants produced enough seed under the bags so that they could be planted in the two tests as one row plots. Since there was only enough seed for a single row plot in each area, the experiment was designed such that there were 10 blocks in the field. Each block contained 20 entries; 18 were S_1 lines and the remaining two were entries of A56-3 which were arbitrarily assigned entry numbers 1 and 2. Since A56-3 appeared twice in each block, it would have been possible to adjust for block effect if there had been any significant differences between blocks.

All data were taken on the plot basis. Since root weight, percentage sucrose, and 3-hydroxytyramine measurements were available on the parents and their progeny, regression analysis of progeny on parent were computed to obtain an estimate of narrow sense heritability. This estimate indicates the proportion of the phenotypic variance that was accounted for by the additive effect of genes controlling the character of interest. Correlations were also calculated to obtain the relationships between the six characters.

Results

An analysis of variance for each character was run on the two entries of A56-3 in the 10 blocks; in no case was the block variance significant. Therefore, no adjustments were made within blocks. The means of A56-3 and the S_1 lines for each character are shown in Table 4.

Table 4. Population means for various characters measured in A56-3 and the S_1 lines.

Character	Means	
	A56-3	S_1 lines
Weight	8.50	7.93
Sucrose	15.28	14.87
Purity	0.93	0.92
3-hydroxytyramine	50.60	50.35
Polyphenoloxidase	1.21	1.19
Leaf spot reading	3.40	4.06

Correlation coefficients for the relationships between characters are shown in Table 5. It should be noted that the degrees of freedom for r differ between the S_1 lines and A56-3, accounting for the differences in the point at which the correlation is significant.

Weight tended to be negatively correlated with sucrose in the S_1 lines and with leaf spot readings in A56-3. Since leaf spot readings are scaled so that the more resistant plants are given a lower value than the more susceptible plants, the negative correlation between root weight and leaf spot readings means that the plants having heavier root weights are, on the average, more resistant to the leaf spot organism. It must be remembered that only the leaf spot readings were made in the disease nursery. The correlations of weight with the other three characters appeared to differ between populations; however, the differences were not statistically significant. Root weight of the S_1 lines had little association with purity and 3-hydroxytyramine but tended to be negatively correlated with polyphenoloxidase. The root weight of A56-3 appeared to be negatively associated with purity and 3-hydroxytyramine but had very little association with polyphenoloxidase. If selection in the S_1 lines was based on high weight, the selected lines would tend to be lower in sucrose and polyphenoloxidase.

Table 5. Correlation coefficients (r) between various characters of the S_1 lines, A56-3, and both populations combined.

Character and population	Character				
	Sucrose	Purity	3-hydroxy-tyramine	Polyphenol-oxidase	Leaf spot reading
Root weight:					
S_1 lines 1/	-0.1582*	0.0243	0.0254	-0.1210	-0.0269
A56-3 2/	-0.0765	-0.4359	-0.3927	0.0773	-0.3748
Combined 3/	-0.1450*	0.0100	0.0052	-0.1125	-0.0495
Percentage sucrose:					
S_1 lines		0.4098**	-0.0333	0.0302	0.1295
A56-3		0.5041*	-0.0710	-0.1284	0.3987
Combined		0.4200**	-0.0350	0.0268	0.1255
Percentage purity:					
S_1 lines			0.0435	-0.0524	0.0429
A56-3			0.1877	-0.1772	0.2129
Combined			0.0518	-0.0541	0.0377
3-hydroxytyramine:					
S_1 lines				-0.7158**	-0.1922**
A56-3				-0.6584**	0.0276
Combined				-0.7101**	-0.1808**
Polyphenoloxidase:					
S_1 lines					0.1115
A56-3					-0.0272
Combined					0.1035

* indicates significance at the 5% level. ** indicates significance at the 1% level.
1/ Degrees of freedom for the S_1 lines are 175. 2/ Degrees of freedom for A56-3 are 18.
3/ Degrees of freedom for the combined populations are 193.

Percentage sucrose in both populations was positively associated with leaf spot readings and particularly purity. It was negatively correlated with weight and had little association with polyphenoloxidase and 3-hydroxytyramine. If selection in the S_1 lines was based upon high percentage sucrose, the selections should generally have a smaller root, be higher in purity, and would tend to be more susceptible to leaf spot.

Percentage purity in the S_1 lines tended to be positively associated with percentage sucrose especially; there was very little association with the other characters. Similar relationships held for A56-3 except weight and purity were negatively associated. If high percentage purity was the criterion for selection in the S_1 lines, the selections would tend to be higher in sucrose.

3-hydroxytyramine in the S_1 lines was negatively associated with polyphenoloxidase and leaf spot readings. There was little association with the other characters. 3-hydroxytyramine in A56-3 was negatively associated with root weight; otherwise, the relationships were similar to those in the S_1 lines. When selecting for high 3-hydroxytyramine in the S_1 lines, the selections would tend to have lower concentration of polyphenoloxidase and higher leaf spot resistance.

Polyphenoloxidase in the S_1 lines was negatively associated with root weight and particularily 3-hydroxytyramine and was positively associated with leaf spot readings and had little association with percentage sucrose or purity. Polyphenoloxidase in A56-3 was negatively correlated with 3-hydroxytyramine. If selection in the S_1 lines was based on polyphenoloxidase, the selections would tend to have smaller roots which would be lower in amounts of 3-hydroxytyramine and the plants would tend to be more susceptible to leaf spot.

Leaf spot readings of the S_1 lines were positively correlated with percentage sucrose and polyphenoloxidase and were negatively associated with 3-hydroxytyramine. There was very little association with root weight and purity. The leaf spot readings of A56-3 had similar associations with the other characters except that it was negatively associated with root weight. If the S_1 lines were selected for leaf spot resistance, there would be a tendency for the selections to have a lower sugar content and the polyphenoloxidase would be lower, but the 3-hydroxytyramine content would be greater.

The progeny-parent regression coefficients for weight, sucrose, and 3-hydroxytyramine which are narrow sense heritability estimates, are shown in Table 6 along with the progeny-parent correlations. The regression and correlation coefficients were determined from data collected on the S_1 lines in 1965 and from data on the individual parents in 1963. According to Falconer (3), the regression of progeny on mid-parent is a measure of the narrow sense heritability; it is an estimate of the phenotypic variance accounted for by variance due to additive genes. In the case of self fertilization the value for the parent is the same as

the mid-parent value in cross fertilization. Thirty-five percent of the phenotypic variance in weight was accounted for by additive variance, 26 percent of that in sucrose was due to additive genes, and 29 percent of the total variance in 3-hydroxytyramine was due to additive variance. The proportion of additive variance in weight has been lower in previous experiments; but as is the case for any heritability estimate, conclusions drawn from these data should be applied only to this particular population of S_1 lines.

The parent and progeny measurements for weight, sucrose, and 3-hydroxytyramine were correlated and it was found that the S_1 lines which had high sucrose had parents that also had high sucrose. The same relationship existed for 3-hydroxytyramine and weight; however, the weight correlation coefficient was not significant. This could be the result of poor stands for some of the S_1 lines which would directly affect root weight.

A crude method of estimating broad sense heritability was used for the three characters. Since the data obtained from A56-3 as well as the S_1 lines were measured on the plot basis and not as individual plants, the A56-3 data should have very little genetic variance. Therefore, plot measurements on A56-3 can be used to estimate the environmental variance which is then subtracted from the total variance of the S_1 lines leaving an estimate of their total genetic variance. This ratio of total genetic variance to total variance estimates broad sense heritability and indicates the expected progress from selection if one is using a breeding method which capitalizes on both additive and nonadditive gene action. These calculations are summarized in Table 7. The broad sense heritability estimates for weight and sucrose are 0.62 and 0.49, respectively. When these estimates are compared with estimates from previous experiments with similar material they appear to be reasonable. Therefore, this method should give a reasonable estimate for 3-hydroxytyramine. The estimate obtained was 0.40 which implies that some progress could be made among these S_1 lines when selecting for high 3-hydroxytyramine provided the proper breeding method was used, but not as much as for weight and sucrose. When the narrow sense heritability estimate for 3-hydroxytyramine from Table 6 is compared with the broad sense heritability estimate, it appears that most of the genetic variability is due to additive genes. A larger proportion is indicated than in the case of weight or sucrose. This indicates that mass selection within these S_1 lines should be an effective means for selecting lines having high concentrations of 3-hydroxytyramine.

Table 6. Narrow sense heritability estimates from progeny-parent regression and progeny-parent correlations for weight, sucrose, and 3-hydroxytyramine.

Character	Heritability h^2	Correlation coefficient
Weight	0.35	0.1077
Percentage sucrose	0.26	0.3715**
3-hydroxytyramine	0.29	0.2700**

Table 7. Broad sense heritability estimates of the pooled S_1 lines.

Character	Total variance of S_1 lines	Estimated environmental variance	Genetic variance	Heritability ratio (broad sense)
Weight	4.6960	1.7863	2.9097	0.62
Percentage sucrose	1.5387	0.7788	0.7599	0.49
3-hydroxytyramine	981.6705	587.7000	393.9705	0.40

Conclusions

Perhaps the most important information derived from this experiment is the fact that high 3-hydroxytyramine in disease-free plants is associated with high leaf spot resistance. High concentrations of either or both 3-hydroxytyramine and its oxidizing enzyme, polyphenoloxidase, are thought to be necessary for high leaf spot resistance but it appears that selection for high amounts of both compounds simultaneously would be somewhat difficult. One might theorize that the negative correlation between the two may be due to the fact that high concentrations of polyphenoloxidase will oxidize the 3-hydroxytyramine; therefore, 3-hydroxytyramine will not be allowed to accumulate. The presence of 3-hydroxytyramine in high concentrations may indicate the lack of enough polyphenoloxidase to oxidize the 3-hydroxytyramine as fast as it is produced. However, this type of mechanism is not the entire answer because a few S_1 lines had high concentrations of both compounds, so it should be possible to make some progress by selecting for both characters simultaneously. This experiment indicates that a considerable portion of the 3-hydroxytyramine variance is due to additive genes which means that mass selection should be an effective method of selecting for high 3-hydroxytyramine lines.

Attempted Transmission of Cytoplasmic Male Sterility across a Vegetative Graft in Sugarbeets

Richard J. Hecker

Introduction

This experiment was conducted for the purpose of detecting the possible transmission of a cytoplasmic male sterility factor across a vegetative graft in sugarbeet (*Beta vulgaris* L.). Such an occurrence would not only be of academic interest but would be of great practical value, since it would provide a rapid and economical means of converting 0 type (non-restorer) sugarbeet populations to the cytoplasmic male sterile state.

Graft induced transmission of cytoplasmic male sterility to progeny in Petunia has been demonstrated by Frankel (4), who reported that male-fertile scions grafted on cytoplasmic male-sterile stocks, though remaining phenotypically unaltered, produced some male-sterile progeny. Edwardson and Corbett (2) generally agreed with this result. Frankel (5) has published experiments corroborating his initial results. Sand (10) was unable to detect a graft transmission of cytoplasmic male sterility in tobacco and concluded that it is not an easily repeatable or else is not a general phenomenon in plants.

Materials and Methods

Plants of five populations were grafted by two methods at two stages of growth. All grafting was done in the greenhouse at Fort Collins, Colorado in 1962 and 1963. The following populations were used:

52-305CMS	green hypocotyl, white root (rryy); inbred; an excellent cytoplasmic male-sterile line; used as the stock (except in four cases).
52-307	red hypocotyl, white root (RRyy); inbred; 0 type; used as a scion (except in one case).
52-407	red hypocotyl, red root (RRYY); inbred; 0 type; used as a scion (except in two cases).
54-346	RRYY; inbred; 0 type; used as a scion (except in one case).
A62-2	rryy; annual (BB); 0 type; used as a scion.

The two growth stages at which grafting was done were 14 to 16 days after planting (cotyledon stage) and 26 to 36 days after planting

(one-to three-leaf stage). A stock and its scion were always the same age. The two methods, wrapped and clipped, were modifications of an approach graft. Both stock and scion plants were split through the meristematic point with the split tapering out about 1/4 to 1/2 inch down the hypocotyl. The split faces were matched as nearly as possible and in the wrapped method were bound using silk thread and a fly tying bobbin. In the clipped method a spring-loaded hair clip was used to hold the cut faces of stock and scion together. The roots of both stock and scion were placed into the soil of the transplanting tube. The thread was removed about 20 days after grafting and the stock crown and scion root were cut about 30 days after grafting. The constriction of the thread necessitated its early removal. In the case of the clipped graft, the stock crown and scion root were severed after about 15 days, but the clips were left in place for about 45 days. All grafted plants were kept in a high humidity chamber until the graft union was established. The two methods are compared in the results section.

A few cleft grafts were attempted, none of which survived to the flowering stage.

All plants were periodically checked and corrected for scion rooting and stock budding; the latter was not a problem.

Following is a list of the successful grafts:

Class	Scion and stock	Number of grafts
I	52-307 on 52-305CMS	40
II	52-407 on 52-305CMS	37
III	52-346 on 52-305CMS	23
IV	A62-2 on 52-305CMS	5
V	52-305CMS on 52-307	1
VI	52-305CMS on 52-407	2
VII	52-305CMS on 54-346	1

Three plants each of classes II and III had their stock crowns left intact but their scion roots severed. Hence they were double crown plants. Asexual cuttings were made from all scions.

All scion plants were examined for male sterility, then self-pollinated and/or pollinated by 52-307, 54-346, or A62-2. The progeny were in turn examined for male sterility.

The four plants of classes V, VI, and VII were included to detect graft transmission of male fertility.

Results

Grafting successes are outlined in Table 1. Grafts using plants in the cotyledon stage, held together with the clips, were most often successful.

Table 1. Effect of age of plant and method on grafting success; all populations considered.

Age and method	Number of attempts	Number of successes	Percent successes
14-16 days after planting:			
Wrapped	200	21	10
Clipped	175	49	28
26-36 days after planting:			
Wrapped	75	9	12
Clipped	180	30	17
Totals	630	109	17

The 105 scions grafted on 52-305CMS were examined for pollen sterility. There was no indication of male sterility; no sterile plants, branches within plants, flowers with branches, or anthers within flowers.

Self-pollinated seed was obtained from 98 of the 105 scions. In each of these 98 progeny lines, 5 to 30 plants were examined for pollen sterility. There was no indication of male sterility among plants or within plants.

Hybrid seed was obtained from 13 of 35 attempted crosses. Following are the successful crosses:

(52-307 on 52-305CMS) X 54-346,F_1	6 plants
(52-307 on 52-305CMS) X A62-2,F_1	1 plant
(52-407 on 52-305CMS) X A62-2,F_1	6 plants

The hybrids were identifiable since 54-346 had a red root and A62-2 was annual. These inbreds used as scions (52-307 and 52-407) are highly self-fertile, partially accounting for the few hybridizations. Also the flowering date of the male and female did not exactly coincide in certain crosses. In each of these 13 F_1 hybrids, 1 to 20 plants were examined for male sterility. There was no indication of pollen sterility among or within plants.

The six plants in which the stock crown was left intact were brought to flower. The inflorescences from the stock were completely sterile; those from the scion all fertile.

In the case of the four plants where 52-305CMS was used as the scion, the scions remained completely male-sterile. These scions were

pollinated by 54-346. Five plants from each of the resulting four F_1 hybrids were completely sterile.

The asexual cuttings were not used since no indication of male sterility was found in their clones or in progeny from their clones.

Discussion

With refinements and practice in the grafting techniques, it is likely that most seedling grafts would be successful.

The 109 graft combinations in this study maintained phenotypic autonomy for at least eight months. In the case of Frankel's work with Petunia (5), the scions and stocks remained unaltered for up to 3 1/2 years. It was among the self-pollinated and F_1 progeny of Petunia that some plants were male-sterile; the proportion of male-sterile progeny appeared to be genotypically controlled.

There was no indication of sterility in any of the self-pollinated or hybrid progeny of sugarbeets in this study. The negative results of this study contribute very little to the explanation of the nature of cytoplasmic male sterility. Gabelman (6), working in corn, concluded that the cytoplasmic male sterility factor was particulate and that reproduction and distribution of the particle was quite similar to that of chromosomes. He was doubtful that a virus would be so dependent on chromosome division for its reproduction and distribution. Edwardson and Corbett (2), however, suggest that cytoplasmic male sterility in Petunia is analogous to a disease resulting from a virus infection. Frankel (5), in order to account for scion autonomy, suggests a "genotype-cytotype interaction" as being responsible for the activation or production of the "virus". Assuming that the cytoplasmic male sterility factor in sugarbeets is particulate it clearly is not a normal virus, since it is axiomatic that viruses are transmitted by grafting between individual plants of a type which they can infect systemically.

It would appear that transmission of cytoplasmic male sterility across a graft union in sugarbeets is not a common occurrence. Hence it is not likely that grafting will ever be an effective means of converting O-type populations to a cytoplasmic male-sterile condition.

Summary

Transmission of a cytoplasmic male sterility or fertility factor through a graft union was attempted in sugarbeets. One hundred nine seedling grafts were made. All graft combinations maintained phenotypic autonomy. Among the self-pollinated and hybrid progeny of the scions there was no indication of transmission of a factor for male sterility or fertility. The transmission of a factor for cytoplasmic male sterility through a graft union does not appear to be a common occurrence in sugarbeets, and it is doubtful that it can ever be an effective means of producing cytoplasmic male-sterile populations.

Computer Method for Calculating Percentage Apparent Purity of Sugarbeet Thin Juice Directly from the Polarization and Refractometer Reading [1/]

George A. Milliken [2/]

Apparent thin juice purity, determined on press juice which has been defecated,using lime and partially neutralized with oxalic or phosphoric acid so that factory thin juice is approximated, has become a common analysis used in sugarbeet research laboratories. The calculation of percentage apparent purity from the polarization and refractometer reading for the thin juice is a time-consuming and costly operation when it is done manually. Hence a method was developed to compute this purity on an electronic computer. A computer is capable of calculating several hundred purities per minute, depending upon size and speed of the machine. The main advantage of using a computer is the elimination of human variation in the calculating and checking processes. A computer is capable of doing a routine operation, such as this, with high accuracy and low cost. The purity of thin juice is being studied more and more by plant breeders because of its importance in sugar production. With this machine method of purity calculation, the plant breeder will be able to do more research with the purity character.

The purity of a sugar solution may be defined as the percentage of total solids (dry substance) of the solution which is sugar as expressed in the simple formula:

$$\text{Purity} = \frac{\text{percent sucrose}}{\text{percent solids}} \times 100. \qquad [1]$$

The laboratory process used to determine percent purity for which this computation program is worked out employs a refractometer and a saccharimeter. The refractometer provides the refractive index and the saccharimeter the polarization of the thin juice. Because the thin juice is a mixed solution and the above two readings are based on the refractive index and polarization of a pure sucrose solution, the resultant determination is called "apparent purity" or more specifically as proposed by Noel Deerr (1) "polarization refractive purity".

A sample of the juice having an unknown purity is placed in a Bausch and Lomb precision refractometer and a reading is taken. The refractive dry substance (RDS) is read from refractometer conversion tables. The remainder of the juice is poured into the saccharimeter and a reading taken.

1/ Acknowledgment is given the breeding research staff of the Great Western Sugar Company for their conceptual and material contributions to the development of this computer method.

2/ Graduate Fellow in the Statistics Laboratory at Colorado State University.

Using the refractive dry substance and the saccharimeter reading (direct polarization), the apparent purity is calculated on a purity wheel.

Apparent purity may also be calculated by

$$\text{APPARENT PURITY} = \text{FACTOR X DIRECT POLARIZATION} \qquad [2]$$

where the factor is determined by

$$\text{FACTOR} = \frac{26.00 \times 100}{99.718 \times \text{sp. gr.} \times \text{Brix}} \qquad [3]$$

where

26.00 is the "normal weight" for sucrose [2/]

99.718 is the apparent density of water at 20° C

sp. gr. is the apparent specific gravity at 20°/20° C water for the Brix of the solution.

Brix in this case is refractive dry substance.

For an example of the manual procedure, consider a sample of thin juice with a polarization of 40.3 and a refractometer reading of 24.29. From the refractometer conversion tables, the RDS is read to be 11.70. Next, using the purity wheel, line up the polarization with the RDS and read the purity to be 85.7. Some error could easily be introduced into the calculation. For example, if the RDS would have been 11.73, it would be hard to gauge exactly the position of the hairline since the wheel is not finely scaled. This error could be as high as 0.2 for the final purity. Another place for error is where the RDS is too small and the tables must be used to obtain the purity. Most of these tables are in increments of 0.05 on the RDS scale and one must interpolate when a value of 7.38, for instance, occurs. In this example, the calculation would usually be made at 7.40. This small discrepancy when applied to many

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[2/] Bates, Frederick J. and Associates. 1942. Polarimetry and Saccharimetry and the Sugars. Cir. C440, U.S. Dept. of Commerce, National Bureau of Standards, p. 79.

"(b) It is recommended that the polarization of the normal solution (26.000 g of pure sucrose dissolved in 100 ml and polarized at 20° C in a 200 mm tube using white light and the dichromate filter as defined by the Commission) be accepted as the basis of calibration of the 100° point on the International Sugar Scale."

Since the polarization is proportional to concentration, the percentage sugar in a solution is the saccharimeter reading x 0.26 which occurs in the numerator of the formula.

samples could introduce some error.

The computer method for calculating the percentage apparent purity is to let a computer determine the refractive dry substance from the refractometer reading and then perform the calculation usually carried out on the purity wheel. Because of the large tables which are required, two equations were obtained to replace them. The first equation approximates the refractive dry substance table, and the second equation approximates the FACTOR (equation [3]) to be used in the purity equation, [2].

A computer was used to determine accurate equations from the tables. This process consists of fitting a polynomial equation to the points in the table by using a polynomial fit computer program. For the refractive dry substance the data points used were all the refractometer readings and their RDS values (23.91, 10.40; 23.92, 10.44; etc.) from the refractometer conversion tables.

Rice (9) calculated a table of factors using equation [3], the factors being wholly determined by the dry substance. The graph of the table was hyperbolic in form. Thus in order to use the polynomial-fit program, the points in the table (0.5, 52.0461; 1.0, 25.9725; 1.5, 17.2814; etc.) were transformed by multiplying each factor by the corresponding dry substance. The transformed data (0.5, 26.0231; 1.0, 25.9725; 1.5, 25.9221; etc.) produced a polynomial equation which could be easily used.

The equations obtained were:

$$\text{RDS} = -109.4991 + (\text{REF}) \times 6.58860 - (\text{REF})^2 \times 0.065836 \qquad [4]$$

where REF = refractometer reading.

$$\text{TRANSFORMED FACTOR} = 26.0731 - (\text{RDS}) \times 0.100654 + (\text{RDS})^2 \times 0.0000453. \qquad [5]$$

$$\text{FACTOR} = \text{TRANSFORMED FACTOR}/\ \text{RDS} \qquad [6]$$

Both of the included tables were fit best by a quadratic equation. For other tables a higher degree polynomial may provide the best fit.

Referring to the above example where the polarization was 40.3 and the refractometer reading 24.29, let us calculate percentage apparent purity using the above equations, thus simulating the computer method.

$$\text{RDS} = -109.4991 + (24.29) \times 6.58860 - (24.29)^2 \times 0.065836$$

$$= -109.4991 + 160.0371 - 38.8435$$

$$= 11.6945$$

$$\text{TRANSFORMED FACTOR} = 26.0731 - (11.6945) \times 0.100654 + (11.6945)^2 \times (0.0000453)$$

$$= 26.0731 - 1.1771 + 0.0062$$

$$= 24.9022$$

$$\text{FACTOR} = 24.9022/11.6945 = 2.1294$$

$$\text{PURITY} = 2.1294 \times 40.3 = 85.8$$

If the calculations were carried out on a calculator, the above equations would not be practical to use, whereas a computer can utilize them very efficiently. If a computer is being used to analyze purity data (analysis of variance or some other statistical analysis), the above equations could be inserted into the program, thus computing the purity before continuing with the analysis.

In order to use the computer method, an equation must be obtained from the refractometer conversion tables since each refractometer has its own set of tables determined by the instrument calibration. To do this, take the refractometer conversion tables to a computer establishment (there is one or more in most areas) and have an equation fit to them. Using this equation and equations [5] and [6] a programmer could write a program which would calculate purity directly from the polarization and refractometer reading. This program is most easily written using the computer language FORTRAN. The one additional step required would be to have the polarization, refractometer reading, identification and other data, as needed, punched in cards.

To show how accurate the approximations are, tables were generated using equation [4] and equations [5] and [6]. Column 2 of Table 1 is a segment of the conversion table used to calculate purity the manual way and column 3 was generated from equation [4]. Comparisons of the dry substance as determined from the table and the computed dry substance show deviations of at most 0.02. Table 2 is a segment of the table of computed factors and compares almost identically (to 0.0001) to Table 3 produced by Rice (9). Table 4 is a check of the accuracy of the method and contains 40 purity calculations from actual data, each one obtained by both methods. The calculation of the dry substance showed an average deviation of 0.0032 and an absolute average deviation of 0.0039. These comparisons show a maximum deviation of 0.01, which is less error than can be accounted for by temperature control which should be held constant at 20° C when obtaining the refractometer reading. The calculation of the purity from the calculated dry substance showed an actual average error of -0.0040 and an absolute average error of 0.0537. The largest deviation between the hand-calculated and machine-computed purities was 0.14. The second purity on the list shows this maximum deviation, but if the purity is recalculated on the purity wheel it turns out to be closer to 89.8 than 89.7. This shows how human error can enter into the calculation.

By using the computer method, the interpolation is carried out for the purities obtained when the dry substance becomes too small to use the purity wheel.

Finally, an average electronic computer can compute these 40 purities in Table 4 in approximately 15 seconds. Even though computers are expensive to operate, the cost of calculating many purities the new way is still much less than calculating and then checking the purities the manual way and is just as accurate.

Table 1. Comparison of tabular and computer calculated refractive dry substance values, using equation [4].

Refractometer reading	Tabular RDS 1/	Computed RDS
21.50	1.70	1.72
22.00	3.58	3.59
22.50	5.42	5.41
23.00	7.22	7.21
23.50	8.98	8.97
24.00	10.71	10.71
24.50	12.41	12.40
25.00	14.07	14.07
25.50	15.70	15.70
26.00	17.29	17.30
26.50	18.86	18.87
27.00	20.39	20.40
27.50	21.90	21.90
28.00	23.38	23.37

1/ These RDS values are from the conversion tables furnished with the Bausch and Lomb precision refractometer at Sugarbeet Investigations, Fort Collins, Colorado.

Table 2. Approximated factor table for purity from polarization and dry substance.

Dry Substance	Factor	Dry Substance	Factor
1.00	25.9725	13.00	1.9056
2.00	12.9360	14.00	1.7624
3.00	8.5905	15.00	1.6382
4.00	6.4178	16.00	1.5296
5.00	5.1142	17.00	1.4338
6.00	4.2451	18.00	1.3487
7.00	3.6244	19.00	1.2725
8.00	3.1588	20.00	1.2039
9.00	2.7968	21.00	1.1419
10.00	2.5071	22.00	1.0855
11.00	2.2701	23.00	1.0340
12.00	2.0726	24.00	0.9868

Table 3. Purity factors for use with dry lead defecation (in factor determination RDS is equivalent to Brix) [Rice (9)].

Brix	Factor	Brix	Factor
1	25.9725	13	1.9056
2	12.9360	14	1.7623
3	8.5905	15	1.6382
4	6.4178	16	1.5296
5	5.1142	17	1.4338
6	4.2451	18	1.3487
7	3.6244	19	1.2725
8	3.1589	20	1.2039
9	2.7968	21	1.1419
10	2.5071	22	1.0855
11	2.2701	23	1.0340
12	2.0727	24	0.9868

Table 4. Comparison of computer with tabular and hand calculated dry substances and apparent purities.

Saccharimeter reading	Refractometer reading	Tabular dry substance	Computer calculated dry substance	Hand calculated purity	Computer calculated purity
40.50	23.95	10.54	10.53	96.10	96.19
42.70	24.33	11.83	11.83	89.70	89.84
42.10	24.05	10.88	10.88	96.70	96.70
43.60	24.15	11.22	11.22	97.00	96.97
35.80	23.57	9.22	9.22	97.70	97.66
42.40	24.17	11.29	11.29	93.80	93.70
43.00	24.13	11.15	11.15	96.30	96.24
44.60	24.22	11.46	11.46	97.00	97.04
42.30	24.12	11.12	11.12	94.90	94.98
41.50	24.00	10.71	10.71	96.90	96.92
38.50	23.93	10.47	10.47	92.10	92.06
19.50	22.43	5.16	5.16	96.50	96.56
42.50	24.14	11.19	11.18	94.80	94.82
50.50	24.70	13.07	13.07	95.80	95.66
50.50	24.64	12.87	12.87	97.40	97.23
44.20	24.25	11.56	11.56	95.30	95.28
44.80	24.15	11.22	11.22	99.60	99.64
40.30	24.29	11.70	11.69	85.70	85.82
46.70	24.40	12.07	12.07	96.30	96.23
45.40	24.34	11.87	11.86	95.30	95.23
44.40	24.28	11.66	11.66	94.90	94.84
45.70	24.36	11.93	11.93	95.30	95.29
36.70	23.68	9.60	9.60	96.00	95.98
41.10	24.06	10.91	10.91	94.10	94.10
47.80	24.52	12.48	12.47	95.10	95.16
41.50	23.97	10.61	10.60	97.80	97.90
44.00	24.24	11.53	11.52	95.00	95.14
41.60	24.03	10.81	10.81	96.20	96.19
41.00	23.99	10.68	10.67	96.00	96.07
42.70	24.17	11.29	11.29	94.40	94.37
35.90	23.69	9.64	9.64	93.50	93.54
46.60	24.40	12.07	12.07	96.10	96.03
40.50	23.94	10.51	10.50	96.40	96.51
40.60	23.90	10.37	10.36	98.10	98.09
41.50	24.04	10.85	10.84	95.60	95.64
43.30	24.18	11.32	11.32	95.40	95.39
46.80	24.36	11.93	11.93	97.60	97.59
41.40	24.06	10.91	10.91	94.80	94.78
38.50	23.84	10.16	10.16	95.00	94.99
41.00	23.94	10.51	10.50	97.70	97.71

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Population Genetic Study Pertaining to Methods of Breeding Sugarbeets[1/]

This experiment is the final phase of a six-year study to obtain fundamental information on methods of breeding for improved root yield and sucrose content in sugarbeets. The components of variance and partitioning methods are used in evaluation of the breeding methods applied.

The breeding methods in this study are limited to mass selection from small units, polycross performance, recurrent selection for general combining ability, and synthetic combinations, each with various modifications. Results of the initial phases of this study, mass selection from small units, and polycross performance, have appeared in the 1960 and 1962 reports.

Materials and Methods

The materials and methods in this experiment consist of phenotypic selection in genetically broad-based monogerm population with these selections being polycrossed and progeny tested. Recurrent selections were made in the polycross test. Five different synthetic or composite populations were developed and are compared with parental and various other populations.

The broad-base monogerm population from which the initial selections were made was developed using SLC 15, a heterogeneous Mendelian self-sterile monogerm line, as the female parent with the following heterogeneous multigerm lines and varieties used as pollinators: GW 359-52R, AC No. 2, Midwest 391, US 201, SL 028, US 400, and Janasz. The resulting population was designated SLC 15 BB_1. From about 15,000 individuals of this population, 753 monogerm segregates were interpollinated to form the population designated as SLC 15 BB_2. This was the parent population from which the initial sucrose and root weight selections were made in these studies on breeding methods. Remnant seed of both these populations remained for use as a measure of possible genetic changes in the population due to the methods of breeding employed.

The phenotypic selections from this genetically broad-based material were made in 1959 using Powers' (5) method of selection from small units. This phase of the study was described in detail in the 1960 report. From about 9,600 individuals of SLC 15 BB_2, the 47 individuals most superior for both percentage sucrose and weight per root were selected and allowed to randomly interpollinate in 1960 in a spatially isolated polycross plot.

1/ Extracted from Ph.D. Dissertation by R. J. Hecker.

A total of five plants died prior to anthesis or failed to bolt and, hence, contributed no gametes. It is recognized that each female gamete should as nearly as possible have equal opportunity of being fertilized by any male gamete in order that the polycross comparisons be theoretically correct. However, due to the need for taking asexual stem cuttings from each plant, it was decided that division of the roots into sections would reduce the likelihood of obtaining sufficient seed for a polycross progeny test. Hence, the whole roots were randomly planted, with stem cuttings being taken just prior to flowering. The asexual cuttings provide a means of maintaining the exact parental genotype.

The polycross test used to measure the general combining ability of the original phenotypic selections was conducted in 1961 and described in the 1962 report. Included in this test were the 33 polycrossed progeny lines for which sufficient seed was available, SLC 15 BB_1, SLC 15 BB_2, an inbred, and an F_1 hybrid. Probabilities of superiority of the progeny lines for both percentage sucrose and weight per root were calculated and used in determining the relative performance of the progeny lines. Only those progeny lines were retained whose probabilities of being truly superior for both characters were greater than 5:1 for weight of root and 4:1 for percentage sucrose. Within these superior progeny lines probabilities of superiority for individual roots were calculated, comparing them with SLC 15 BB_2. Recurrent selections were then made within the seven most superior progeny lines. This is a modification of recurrent selection for general combining ability as described by Allard (1).

Recombinations of the selected material based on progeny performance were made in 1962 in three separate spatially isolated plots. One plot consisted of the 46 best individual recurrent selections, with respect to both weight of root and percentage sucrose, selected from the seven superior progeny lines. Four of these individuals died prior to anthesis; hence, there were only 42 recurrent selections included in this interpollinating group. The second plot consisted of the five phenotypically most superior individuals among the 46 recurrent selections. By halving these five roots they were included in both the first and second plots. The third polycross plot consisted of asexual propagations of those seven individuals which gave rise to the seven superior progeny lines. All propagants of two of these individuals died prior to anthesis and, hence, did not contribute to the resulting synthetic population. These five surviving asexually propagated lines then represent modified recurrent selections for general combining ability and are the actual genotypes which demonstrated the superior combining ability, not just samples or out-pollinated samples of the superior combining genotypes. As such, advance in superior combining ability due to recurrent selection should on an average be enhanced relative to recurrent selection based on top cross performance as is practiced in corn.

Progeny performance of recurrent selections was not determined on an individual basis; they were, for the purposes of this study, compared as synthetic populations.

A population genetic study was conducted in 1963 as the final phase of the experiment. Following are those populations included in this population genetic study.

1. Polycross composite of five superior combiners.
   This population resulted from compositing the polycrossed seed of those five individuals which exhibited the highest combining ability for both weight per root and percentage sucrose. Hence, it represents a genetic sample of the five highest combining individuals pollinated by all 42 surviving original mass-selected individuals.

2. Polycross composite of all original selections.
   This population resulted from compositing in equal quantity the polycrossed seed of all 42 surviving mass-selected individuals. Hence, it represents a single cycle of simple mass selection.

3. Synthetic of five superior combining selections.
   This population resulted from recombining asexual propagations of five originally selected individuals which exhibited superior general combining ability for both weight per root and percentage sucrose. Hence, it represents a recombination of those genotypes with the highest general combining ability.

4. A56-3.
   This population is a multigerm commercial variety adapted to the eastern slope region of the Rocky Mountains. It is included to provide a commercial and genetic comparison, since genetic information on this variety is available at Fort Collins, Colorado, dating from 1955.

5. Synthetic of all recurrent selections.
   This population resulted from the recombination of the 42 surviving phenotypically superior individuals selected from the seven superior progeny lines. Hence, it represents the first cycle of recurrent selection based on general combining ability.

6. Synthetic of five superior recurrent selections.
   This population resulted from the recombination of the five phenotypically most superior individuals selected from the seven superior progeny lines. Hence, it represents a genetically narrow based first cycle of recurrent selection for general combining ability. Actually these five individuals were selected from only four progeny lines. Hence, two of these recurrent selections had a common maternal parent.

7. SLC 15 BB_2.
This is the genetically broad-based monogerm population from which the original mass selections were made.

8. SLC 15 BB_1.
This is the first open-pollinated generation of the genetically broad-based population. It is segregating for the monogerm character.

9. 52-305CMS X 52-407.
This is the F_1 hybrid resulting from the crossing of the cytoplasmic male-sterile inbred 52-305 with the inbred 52-407.

10. 52-430 X 52-407.
This is the F_1 hybrid resulting from the crossing of the inbred 52-430 with the inbred 52-407 and is the same F_1 hybrid included in the 1959 and 1961 phases of this study.

11. 52-305CMS.
This is a cytoplasmically male-sterile inbred line in the fifth backcross (B_5) generation using the male-fertile inbred 52-305 as a recurrent parent. This recurrent parent is a longtime very uniform inbred.

12. 52-407.
This is a longtime very uniform inbred.

This population genetic study was planted in a randomized complete block design with forty replications. The single 20-foot rows were all bordered by a common competitor. The between-row spacings were 22 inches and all plots were thinned within rows to about 10-inch between plant spacings. Ten competitive roots were harvested from each plot, giving a total of 400 individuals in each population. All roots were individually analyzed for weight per root and percentage sucrose.

Since many of the methods of analysis are somewhat unique, they are described and exemplified in the results section at the time of their application.

Experimental Results

The results of selection from the parental population and polycrossed progeny performance will be reviewed only briefly. The results of the 1963 population genetic study will be reported in some detail.

Selection from the Parental Population

Means for percentage sucrose for the inbred, F_1 hybrid, and SLC 15 BB_2 in the 1959 selection study are included in Table 1. An analysis of variance of these sucrose data (see 1960 Report) reveals that there are differences between the population means and unit means. The population by unit interaction is also significant. The nonsegregating populations have homogeneous variances for percentage sucrose and their frequency distributions do not deviate significantly from normal. It, therefore, appears that either of the nonsegregating populations, or an average of both, could be used as an estimate of the environmental variability. Using the F_1 hybrid to estimate the environmental variance and the inbred as an empirical test of the methods, the variance of SLC 15 BB_2 for percentage sucrose was partitioned into environmental and genetic components. This genetic component was quite large, indicating that there is considerable genetic variability in this population. Hence, there should be a chance for improvement by breeding. Using methods of Powers et al. (7), the frequency distribution for percentage sucrose of SLC 15 BB_2 was partitioned to determine the proportion of identifiable genetic deviates which allowed the prediction of genetic gains. Six individuals in the frequency distribution of 640 plants of SLC 15 BB_2 were shown to have a high probability of being superior genetic deviates and were considered to be identifiable genetically superior individuals. They constituted 0.94 percent of the population. With this percentage of genetically superior individuals it is possible to predict genetic gains theoretically obtainable in SLC 15 BB_2. These predicted gains are compared with obtained gains in the 1963 population genetic study.

Table 1. Means for percentage sucrose for different years and populations.

Population	Year		
	1959	1961	1963
SLC 15 BB_2	11.51	14.97	16.78
SLC 15 BB_1		14.86	16.60
Pooled progeny lines		15.55	
Polycross composite of five superior selections			16.80
Polycross composite of all selections			16.83
Synthetic of five superior selections			16.52
A56-3			16.92
Synthetic of all recurrent selections			17.14
Synthetic of five superior recurrent selections			17.14

Means for weight per root in the 1959 selection study are included in Table 2. The mean-variance relationship for the inbred and F_1 hybrid was calculated, with 96.9 percent of the variation among within plot variances being accounted for by regression of variances on means. In this case linear regression appears to do a creditable job of describing the relationship between the means and variances in the nonsegregating populations. This relation is then used to estimate the environmental variance of SLC 15 BB_2. The resulting component of genetic variance was relatively large, indicating that some progress should be possible in breeding for improved weight per root. Using methods of Powers (7), the frequency distribution for weight per root of SLC 15 BB_2 was partitioned to determine the proportion of identifiable genetic deviates which then allowed the prediction of genetic gains theoretically possible in the population. Twelve individuals in the frequency distribution of 640 plants were considered to be identifiable genetically superior individuals for weight per root. They constituted 1.9 percent of the population. From this proportion of genetically superior individuals it is possible to predict genetic gains theoretically obtainable in SLC 15 BB_2. These predicted gains are compared with some of the obtained gains in the 1963 population genetic study.

Table 2. Means for weight per root in kilograms for different years and populations.

Population	Year		
	1959	1961	1963
SLC 15 BB_2	0.629	1.058	1.045
SLC 15 BB_1		1.093	1.040
Pooled progeny lines		1.120	
Polycross composite of five superior selections			1.111
Polycross composite of all selections			1.076
Synthetic of five superior selections			1.206
A56-3			1.100
Synthetic of all recurrent selections			1.046
Synthetic of five superior recurrent selections			1.005

Considering both characters simultaneously, the proportion of individuals genetically superior for both percentage sucrose and weight per root should be (0.019)(0.0094) = 0.000179. Thus, assuming independence, approximately two individuals per 10,000 would be expected to fall into classes that would make them identifiable as genetically superior for both characters. In the bivariate frequency distribution of 640 plants of SLC 15 BB_2,

no individuals superior for both characters would be expected to be found, and none were found. Since there were about 9,600 plants of SLC 15 BB_2 from which selections were made, about two of the 47 roots selected to go into the polycross progeny test could be expected to be genetically superior.

Polycross Progeny Performance

Thirty-three of the 47 initial selections produced sufficient seed to be included in the 1961 polycross progeny test. The performance of these progeny lines is reported in detail in the 1962 Report.

Means for percentage sucrose from this test for pooled progeny lines, SLC 15 BB_2, SLC 15 BB_1, inbred 34, and the F_1 hybrid 52-430 X 52-407 are included in Table 1. Weight per root means for these same populations are included in Table 2.

Seventeen of the 33 progeny lines have odds greater than 99:1 of being superior to SLC 15 BB_2 for percentage sucrose. For weight per root there is only one progeny line with odds greater than 99:1, four with odds greater than 19:1, and 12 with odds of 5:1 or greater. These comparisons would indicate that improvement of weight per root has not been as general nor extensive as for percentage sucrose. In considering these characters simultaneously there are only two progeny lines which have odds greater than 19:1 for both characters of being superior to SLC 15 BB_2. This corresponds quite well with the results obtained from the 1959 study when SLC 15 BB_2 was partitioned, indicating the presence of about two identifiable genetically superior individuals per 10,000.

Forty-six recurrent selections were made within the seven progeny lines most superior for both characters. In choosing these seven best progeny lines it was necessary to accept odds as low as 4:1 for one or the other character. Interpollination of these 46 recurrent selections resulted in population 5 in the 1963 population genetic study. Roots of the five phenotypically most superior recurrent selections were halved so that they could be included in the plot of 46 and in a separate isolation of five. Interpollination of these five resulted in population 6 in the 1963 population genetic study.

It will be noted from Table 1 that the mean of the pooled progeny lines for sucrose is 15.55 percent. This is significantly higher than SLC 15 BB_2 at 14.97 percent. Hence, on the average these selected individuals combine with each other better than does the average of the population. This indicates that selection of superior genetic deviates for percentage sucrose has produced superiority in general combining ability also. The total within plot and genetic variances of the pooled progeny lines are not different

than those of SLC 15 BB_2. Hence, considering all progeny lines as a single population, the mean for percentage sucrose has been increased while the genetic variance has not been changed.

As regards weight per root, the mean for pooled progeny lines in Table 2 is significantly higher than the mean of SLC 15 BB_2. Therefore, these selected individuals combine with each other better than does the average of all individuals in SLC 15 BB_2. As in the case of percentage sucrose, this indicates that selection of superior phenotypic deviates has resulted in selection of plants possessing higher than average general combining ability.

Population Genetic Study

The 1963 population genetic study consists of the 12 populations described in the materials and methods section. Four of these are non-segregating populations. By including four homozygous populations there is less likelihood that the estimated environmental variance will be affected by a genotype environment interaction.

In order to compare all frequency distributions directly for both characters without requiring assumptions of normality of the environmental frequency distribution, the frequency distributions are freed of replication and population mean effects using methods developed by Powers et al. (6). Through the use of these methods the frequency distributions are subject only to within-plot sources of genetic and environmental variation. In the case of replications, this is done by calculating the difference between the mean of any given plot and that of its respective population and adding or subtracting, as the case may be, this difference from the value for each plant in the given plot. In equalizing population means each observation within a population is readjusted on the basis of the difference between the mean of a given population and the mean of all populations in the experiment. Direct comparison of all population distributions eliminates the need of estimating the distribution due to the environment based on obtained distributions of nonsegregating populations. This is a nonparametric or distribution free method eliminating the necessity of making assumptions about the distributions. However, it remains necessary to assume that the genotype environment interaction is negligible or at least is the same for all genotypes.

Percentage sucrose

The twelve population means and their standard errors for percentage sucrose are listed in Table 3. Using a least significant difference at the 0.95 probability level and comparing population 7 (SLC 15 BB_2) with all other populations, it is apparent from Table 3 that those with higher means are population 5 (synthetic of all recurrent selections), population 6

(synthetic of five superior recurrent selections), and population 11 (inbred 52-305CMS). Those with lower means are population 3 (synthetic of five superior selections), population 8 (SLC 15 BB_1), population 9 (52-305CMS X 52-407, F_1), and population 12 (inbred 52-407). The remaining populations can not be shown to be different than SLC 15 BB_2.

Table 3. Means, total variances, total within-plot variances, genetic variances, and heritability ratios for percentage sucrose in the 1963 population genetic study.

Population number	Population	Mean	Variance 1/ Total	Variance 1/ Total within-plot	Variance 1/ Genetic	Heritability ratio
1	Polycross comp. of 5 sup. sel.	16.8030±0.0602	1.451169	1.022048	0.237731	0.233
2	Polycross comp. of all sel.	16.8298±0.0662	1.753474	1.038822	0.254505	0.245
3	Syn. of 5 sup. selections	16.5220±0.0658	1.733450	1.144560	0.360243	0.315
4	A56-3	16.9155±0.0666	1.772140	1.199205	0.414888	0.346
5	Syn. of all recurrent sel.	17.1428±0.0632	1.595586	1.007395	0.223078	0.221
6	Syn. of 5 sup. recurrent sel.	17.1372±0.0558	1.245652	0.860930	0.076613	0.089
7	SLC 15 BB_2	16.7840±0.0665	1.768164	1.133138	0.348821	0.308
8	SLC 15 BB_1	16.5970±0.0630	1.588061	1.177392	0.393075	0.334
9	52-305CMS X 52-407	16.6305±0.0603	1.452952	0.841342	0.057025	0.068
10	52-430 X 52-407	16.7665±0.0538	1.156268	0.714655	-0.069662	
11	52-305CMS	17.6445±0.0576	1.327839	0.841228	0.056911	0.068
12	52-407	14.5075±0.0624	1.555282	0.740042	-0.044275	

$LSD_{0.05}$ = 0.1370

1/ Estimated environmental variance is the mean total within-plot variance of populations 9, 10, 11, and 12.

Duncan's (9) multiple range test, Table 4, shows the same populations to be different from SLC 15 BB_2. Since this multiple range test allows all possible comparisons to be made it is less precise than a t test. For these particular comparisons, however, there happens to be no difference.

The populations of principal interest are those resulting from selection and recombination, i.e., population 1 (polycross composite of five superior selections), population 2 (polycross composite of all selections), population 3 (synthetic of five superior selections), population 5 (synthetic of all recurrent selections), and population 6 (synthetic of five superior recurrent selections). Among these, the percentage sucrose of populations 5 and 6 has been increased relative to SLC 15 BB_2; in populations 1 and 2 it has not been changed; and in population 3 it has been decreased. Population 2 should be approximately the same as the mean for pooled progeny lines in 1961, since it is merely a composite of seed from the 33 progeny lines and the nine additional progeny lines for which there was insufficient seed to be included in the 1961 progeny test. The mean of pooled progeny lines in 1961 was significantly higher than SLC 15 BB_2, while in 1963 population 2 was not different than SLC 15 BB_2. It is not surprising that population 1 is not different than population 2,since the mean of the five superior progeny lines in 1961 was 15.56 percent compared with a mean of 15.55 for all progeny lines. Hence, in determining the five superior progeny lines nearly all selection pressure was applied to weight per root with sucrose percentage merely being maintained. Among the progeny lines, these five possessed average general combining ability for percentage sucrose.

The recurrent selections have no comparison in 1961,but the mean of the seven progeny lines from which all recurrent selections were made was 15.60 in 1961 as compared to a mean of 14.97 for SLC 15 BB_2. Hence, recurrent selections were made within those progeny lines which exhibited only slightly higher than average general combining ability.

Table 4. Multiple range test for percentage sucrose in the 1963 population genetic study.

Population no.	11	5	6	4	2	1	7	10	9	8	3	12
Mean	17.644	17.143	17.137	16.916	16.830	16.803	16.784	16.766	16.630	16.597	16.522	14.508

Note: Any two means not underscored by the same line are significantly different at the 5-percent point.

An examination of the variances in Table 3 is helpful in interpreting the means. The total variances include all sources of variation within a population. Removal of the variation due to replications and replication by population interaction results in the total within-plot variance. There are 399 degrees of freedom associated with each total variance but only 360 associated with each total within plot variance. An F test can be used in determining whether or not particular variances are different. To determine the value of the four nonsegregating populations (populations 9, 10, 11, and 12) as a measure of the environmental variance, the F test shows that there are no differences between any of these four total within-plot variances. A regression analysis shows there is no significant relation between the means and the variances. Hence, the mean total within-plot variance of the four nonsegregating populations should provide a good estimate of the environmental variance for percentage sucrose in the 1963 experiment. This estimate of environmental variance, 0.784317, has 1440 degrees of freedom. Any within-plot variance significantly larger than this must also have a genetic variance significantly larger than zero. Population 6 is the only one of the eight segregating populations which does not have a significant genetic variance. Excluding population 6, differences could not be demonstrated between within-plot variances of the remaining seven segregating populations. Since a common estimate of the environmental variance was subtracted from each to estimate the genetic variance, there can be no significant differences among their genetic variances. Transformation of the sucrose data to common logarithms introduced heterogeneity into the variances. For this reason the nontransformed sucrose data are considered to be a more satisfactory scale and are used throughout the 1963 experiment.

Returning to an examination of Table 3, some information can be gained by a study of the total within-plot variances, but the genetic variances are of principal interest. If any two total within-plot variances are significantly different using the F test, then their genetic variances, resulting from the subtraction of a common estimate of environmental variance, must be different. Using this test the genetic variance of population 6 is significantly lower than populations 3, 4, 7, and 8 but not different than populations 1, 2, and 5. These are the only significant differences among all the genetic variances.

It is assumed that 0.076613 is the best estimate of the genetic variance of population 6 even though it cannot be demonstrated that this genetic variance is significantly different than zero. All other genetic variances are significantly greater than zero, as was pointed out above. The genetic variance of population 6 has been drastically reduced relative to that of SLC 15 BB_2, yet its mean is significantly higher. It should be remembered that the five individuals recombined to form this population were superior plants within the seven best progeny lines. Two of the five came from the same progeny line; hence, they have a common maternal parent. This alone would not be expected to account for the drastic reduction in genetic variance. The means of populations 1 and 2 are not different than

SLC 15 BB_2 but their variances are somewhat reduced. The mean of population 3 is significantly lower than that of SLC 15 BB_2, while its variance is about the same. This seems somewhat contradictory since the five plants in population 3 are the maternal parents of the five best general combining lines in the polycross test of the 33 progeny lines. Those individuals with the highest general combining ability apparently do not combine well with each other. From this it might be assumed that these five individuals had near the same genotype. These relationships will be considered further in a joint discussion with weight per root.

The frequency distributions of percentage sucrose for the 12 populations are shown in Table 5. They are adjusted to eliminate differences between replications within populations and differences between populations. They have a common mean and can be compared directly. The mean of these distributions is 16.69 percent, which is the experimental mean; the class widths are 0.75 percent; and the upper limit of the first class is 6.00 percent. The mean distribution of the four nonsegregating populations is used as the estimated environmental distribution. The differences in Table 6 result from the subtraction of this mean distribution from each population in the study. The approximate points of intersection of the obtained and environmental distribution curves, where the ordinates of the two curves are equal, occur where the differences change from positive to negative and vice versa. The segregating distributions are partitioned at these class intervals, from Powers et al. (7), and the differences in the classes to the left and right of the partition lines, intersection of the distribution curves, represent the identifiable numbers of superior and inferior genetic deviates in the population. These identifiable numbers of genetic deviates rounded to the nearest whole numbers are listed in Table 7. Their standard errors are $\sqrt{pqn}$ where q is the proportion of genetic deviates, p = 1-q, and n is the sample size, 400 in this case. Assuming normality those populations with the greatest proportion of identifiable genetic deviates should be those with the greatest genetic variance in proportion to the total within-plot variance. This relationship was investigated by Powers et al. (6) where they found correlations from 0.76 to 0.93 between identifiable numbers of genetic deviates and heritability ratios. Before examining this relationship in these data, remarks by Robson and Powers (8) should be considered. They state that for the normal case the proportion of genetic deviates is a monotone (increasing) function of the heritability ratio (h^2) and is for this reason equivalent to h^2 as a heritability index. They go on to state that when the genotypic distribution is non-normal the two indices are no longer equivalent and that in general neither can be regarded as an adequate index of heritability in the sense of uniquely determining the genotypic distribution for a given phenotypic distribution.

Table 5. Obtained frequency distributions 1/ for percentage sucrose in the 1963 population genetic study.

Population number and population	Class															
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 Polycross composite of 5 sup. selections						2	1	14	42	100	129	83	22	7		
2 Polycross composite of all selections				1		1	2	12	44	92	139	83	19	7		
3 Synthetic of 5 superior selections							3	19	46	99	125	71	30	6		1
4 A56-3			1				4	10	51	90	138	70	26	7	2	1
5 Synthetic of all recurrent selections						1	4	18	35	103	124	86	28	1		
6 Synthetic of 5 sup. recurrent selections				1			1	8	38	111	139	81	19	1	1	
7 SLC 15 BB_2						1	4	14	49	98	127	68	30	7	1	1
8 SLC 15 BB_1						1	3	16	50	98	111	79	33	9		
9 52-305CMS X 52-407							3	5	43	114	140	69	20	5	1	
10 52-430 X 52-407							2	4	37	129	130	71	27			
11 52-305CMS	1							5	31	128	137	76	19	3		
12 52-407							2	5	38	120	148	65	15	7		

1/ Each distribution consists of 400 individuals.

Table 6. Differences between the obtained distributions and the estimated environmental distribution for percentage sucrose in the 1963 population genetic study.

Population number and population	Class 1/ 14	15	16	17	18
1 Polycross composite of 5 superior selections	15	-23	-10	13	5
2 Polycross composite of all selections	16	-31	0	13	2
3 Synthetic of 5 superior selections	24	-24	-14	1	13
4 A56-3	22	-33	- 1	0	12
5 Synthetic of all recurrent selections	14	-20	-15	16	5
6 Synthetic of 5 superior recurrent selections	4	-12	0	11	- 3
7 SLC 15 BB_2	24	-25	-12	- 2	15
8 SLC 15 BB_1	26	-25	-28	9	18
9 52-305CMS X 52-407	7	- 9	1	- 1	2
10 52-430 X 52-407	- 1	6	- 9	1	3
11 52-305CMS	- 7	5	- 2	6	- 2
12 52-407	1	- 3	9	- 5	- 2

1/ End classes of the environmental distribution are grouped to include at least ten observations in each class.

Table 7. Heritability ratios and identifiable numbers of genetic deviates for percentage sucrose in the 1963 population genetic study.

Population number and population	Heritability ratio	Identifiable numbers of genetic deviates		
		Superior	Inferior	Total
1 Polycross composite of 5 superior selections	0.233	18±4	15±4	33±6
2 Polycross composite of all selections	0.245	15±4	16±4	31±5
3 Synthetic of 5 superior selections	0.315	14±4	24±5	38±6
4 A56-3	0.346	12±3	22±5	34±6
5 Synthetic of all recurrent selections	0.221	21±4	14±4	35±6
6 Synthetic of 5 superior recurrent selections	0.089	8±3	4±2	12±3
7 SLC 15 BB_2	0.308	13±4	24±5	37±6
8 SLC 15 BB_1	0.334	27±5	26±5	53±7

Tests of normality for the segregating populations and the pooled nonsegregating populations were made. These tests indicated that the environmental distribution estimated from the four nonsegregating populations deviated significantly from a normal distribution. Populations 2 and 4 also deviated significantly from normal, while all other segregating populations were not distributed significantly different than normal. Since the method of partitioning the distributions and calculating the number of genetic deviates is distribution free, these deviations from normality are immaterial except in comparison of identifiable numbers of genetic deviates and heritability ratios.

The correlations between the identifiable numbers of genetic deviates and broad sense heritability ratios are listed in Table 8 for percentage sucrose. The correlation with identifiable numbers of superior genetic deviates is not significant, while that with identifiable numbers of inferior genetic deviates is quite high, 94 percent of the variability being accounted for by regression. The correlation with total identifiable numbers of genetic deviates is significant but somewhat reduced.

Table 8. Simple correlation coefficients between heritability ratios and identifiable numbers of genetic deviates for percentage sucrose in the 1963 population genetic study.

Superior		Inferior		Total	
r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$
0.39	15	0.97**	94	0.84**	70

Weight per root

An analysis of variance of the data for kilograms per root (not shown) reveals that there are significant differences between populations and between replications. There is no measurable population by replication interaction.

The twelve population means and their standard errors are listed in Table 9. Using a least significant difference at P = 0.05 and comparing SLC 15 BB_2 with all other populations, populations 1, 3, and 10 have larger means, populations 11 and 12 have smaller means, and the remaining populations are not different. The multiple range test, Table 10, indicates that only populations 3 and 10 have larger means than SLC 15 BB_2. However, as was stated previously the multiple range test sacrifices precision for the liberty of making all possible comparisons. Certain other mean comparisons from Table 10 are of interest, however. For instance the mean of population 3 is significantly larger than any other segregating population, the means of populations 1 and 4 are larger than the mean of population 6, while all remaining comparisons are not significantly different. Hence, significant progress has been made in two of the five populations resulting from selection; that is, population 1 (polycross composite of five superior selections) and population 3 (synthetic of five superior selections). Population 3 exceeds even the adapted commercial variety, population 4.

Table 9. Means, total variances, and their standard errors for weight per root in kilograms in the 1963 population genetic study.

Population number and population	Mean	Total variance
1 Polycross composite of five superior selections	1.111000$\pm$0.02814	0.316834$\pm$0.022432
2 Polycross composite of all selections	1.075500$\pm$0.02549	0.259862$\pm$0.018398
3 Synthetic of five superior selections	1.206000$\pm$0.02684	0.288122$\pm$0.020399
4 A56-3	1.099750$\pm$0.02725	0.297043$\pm$0.021030
5 Synthetic of all recurrent selections	1.045625$\pm$0.02549	0.259962$\pm$0.018405
6 Synthetic of five superior recurrent selections	1.004750$\pm$0.02506	0.251231$\pm$0.017787
7 SLC 15 BB_2	1.044875$\pm$0.02434	0.237035$\pm$0.016782
8 SLC 15 BB_1	1.039500$\pm$0.02330	0.217158$\pm$0.015375
9 52-305CMS X 52-407	1.010500$\pm$0.02029	0.164664$\pm$0.011658
10 52-430 X 52-407	1.200375$\pm$0.022516	0.202788$\pm$0.014357
11 52-305CMS	0.485000$\pm$0.00757	0.022907$\pm$0.001622
12 52-407	0.754250$\pm$0.01228	0.060333$\pm$0.004272
$LSD_{0.05}$ = 0.064615		

Table 10. Multiple range test for weight per root in kilograms in the 1963 population genetic study.

Population no.	3	10	1	4	2	5	7	8	9	6	12	11
Mean	1.2060	1.2004	1.1110	1.0998	1.0755	1.0456	1.0449	1.0395	1.0105	1.0048	0.7542	0.4850

Note: Any two means not underscored by the same line are significantly different at the 5 percent point.

Population 2 should approximate the performance of the mean of pooled progeny lines in the 1961 study. In 1961 the mean of pooled progeny lines was significantly larger than SLC 15 BB_2, while in 1963 population 2 was larger than SLC 15 BB_2 but not significantly so. This is the same relationship as was noted previously for percentage sucrose.

The mean of the seven progeny lines from which recurrent selections were made in 1961 was 1.1952 kilograms per root. This is significantly larger than the mean of all progeny lines, t being 3.27 with 3998 degrees of freedom. This superiority was not evidenced in the 1963 populations from recurrent selections, populations 5 and 6, which are not different than SLC 15 BB_2 nor are they different from each other. Possible reasons for this will be discussed later. The mean of the 42 surviving recurrent selections from the seven superior progeny lines was 1.8738 ± 0.0522, and the mean of the five most superior of these 42 recurrent selections was 2.2100 ± 0.0886. The relationships of these populations will be discussed in the succeeding section.

Among the nonsegregating populations a positive relationship exists between the means and total within-plot variances with 94.6 percent of the variability of the variances being accounted for by regression. Using estimates of environmental variance developed from this relationship, the total within-plot variances were partitioned into environmental and total genetic components (not shown). However, transformation of this weight per root data to common logarithms eliminated the mean-variance relationship. Using the same regression analysis that was used on the untransformed data, the regression of mean log weight per root and their variances was not significantly different than zero and the mean-variance correlation was not significant. This being the case, the best estimate of the environmental variance should be provided by the mean of the total within-plot variances for the four nonsegregating populations. Subtracting this estimated environmental variance from the total within-plot variance of each of the segregating populations results in the estimates of the genetic variance in Table 11. As in the case of the untransformed data, there are some significant differences between the total within-plot variances of the nonsegregating populations. This would indicate that some of these populations are segregating or that transformation to the logarithmic scale did not entirely remove the heterogeneity among the variances. The latter is most likely.

Table 11. Means, total variances, total within-plot variances, genetic variances, and heritability ratios for log weight per root in the 1963 population genetic study.

Population no. and population	Mean	Total variance	Total within plot variance	Genetic variance	Heritability ratio
1 Polycross composite of five superior selections	-0.00940573±0.0112536	0.0506578	0.0534680	0.0256306	0.479
2 Polycross composite of all selections	-0.02159682±0.0112763	0.0508622	0.0521062	0.0242688	0.466
3 Synthetic of five superior selections	0.03185359±0.0110674	0.0489947	0.0496488	0.0218114	0.439
4 A56-3	-0.01409220±0.0114439	0.0523847	0.0544453	0.0266079	0.489
5 Synthetic of all recurrent selections	-0.03239887±0.0110034	0.0484298	0.0502589	0.0224215	0.446
6 Synthetic of five superior recurrent selections	-0.05985670±0.0122945	0.0604622	0.0630696	0.0352322	0.559
7 SLC 15 BB_2	-0.02890321±0.0105862	0.0448267	0.0451392	0.0173018	0.383
8 SLC 15 BB_1	-0.03057024±0.0106313	0.0452100	0.0465466	0.0187092	0.402
9 52-305CMS X 52-407	-0.03385479±0.0095945	0.0368217	0.0362932	0.0084558	0.233
10 52-430 X 52-407	0.04625381±0.0088413	0.0312674	0.0292738	0.0014364	0.049
11 52-305CMS	-0.33693115±0.0072913	0.0212654	0.0206611	-0.0071763	
12 52-407	-0.14866435±0.0079626	0.0253615	0.0251213	-0.0027161	

It is apparent that neither regression nor transformation to logarithms is a completely satisfactory method of partitioning the variance into environmental and genetic components. However, considerations in the comparisons of frequency distributions make the use of the transformed data more desirable. Partitioning of the frequency distributions will, therefore, be done on the transformed data.

Frequency distributions for the 12 populations are shown in Table 12. These are from data transformed to logarithms then adjusted to eliminate differences between replications within populations and differences between populations. The distributions have a common mean and can be compared directly. The mean of these distributions is -0.05318, the class interval is 0.060, and the upper class limit of the first class is -0.720. The mean distribution of the four nonsegregating populations is used as the estimated environmental distribution. The distribution of differences in Table 13 results from the subtraction of this mean distribution from each of the segregating populations in the study. The end classes are grouped such that the environmental distribution had a minimum of ten in each of its end classes. The distributions are partitioned at the approximate points of intersection of the obtained and environmental curves, as was done for percentage sucrose.

Table 12. Obtained frequency distributions for log weight per root in the 1963 population genetic study.

Population no. and population	Class 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Polycross comp. of 5 sup. sel.	1		3	6	6	10	13	16	18	29	27	59	48	44	38	20	26	18	9	4	5		
2 Polycross comp. of all sel.	2		4	4	6	9	11	21	22	27	35	30	48	53	42	35	20	21	9		1		
3 Syn. of 5 superior sel.	2	1	1	3	9	13	15	25	11	27	39	36	49	48	50	32	27	14	6	2			
4 A56-3		3	2	6	7	7	13	22	21	24	38	33	47	45	44	38	16	15	14	2	3		
5 Syn. of all recurrent sel.	1	1	3	5	5	6	9	17	29	22	42	47	42	49	40	35	19	12	8	5	2	1	
6 Syn. of 5 sup. recurrent sel.	2	1	3	7	7	13	17	14	30	20	33	26	38	42	37	45	31	18	11	3	2		
7 SLC 15 BB_2	1		6	1	4	4	13	19	18	30	42	49	47	41	47	34	26	8	6	2	1	1	
8 SLC 15 BB_1		1	3	3	5	8	7	19	25	35	36	46	39	45	46	37	26	8	7	1	2		1
9 52-305CMS X 52-407		1	1	5	2	5	11	14	21	23	41	53	60	53	47	31	17	10	4	1			
10 52-430 X 52-407		1	3		2	2	11	12	20	22	50	57	53	60	63	25	12	7					
11 52-305CMS			2		2	1	3	3	20	26	55	72	78	52	51	25	6	4					
12 52-407	1	1		2		2	7	15	16	29	36	67	66	68	52	30	7	1					

Table 13. Differences between the obtained distributions and the estimated environmental distribution for log weight per root in the 1963 population genetic study.

Population number and population	Class 1/										
	7	8	9	10	11	12	13	14	15	16	17
1 Polycross composite of 5 superior selections	23	5	-2	4	-19	-3	-16	-14	-15	-8	45
2 Polycross composite of all selections	20	10	2	2	-11	-32	-16	-5	-11	7	34
3 Synthetic of 5 superior selections	18	14	-8	2	-7	-27	-15	-10	-3	4	32
4 A56-3	22	11	1	-1	-8	-29	-17	-13	-9	10	33
5 Synthetic of all recurrent selections	14	6	10	-3	-4	-15	-22	-10	-13	7	30
6 Synthetic of 5 superior recurrent selections	34	3	11	-5	-13	-36	-26	-17	-16	17	48
7 SLC 15 BB_2	13	8	-1	5	-4	-13	-18	-17	-6	6	27
8 SLC 15 BB_1	11	8	5	10	-10	-16	-25	-13	-7	9	28
9 52-305CMS X 52-407	9	3	2	-2	-5	-9	-5	-5	-6	3	15
10 52-430 X 52-407	3	1	1	-3	4	-5	-11	2	9	-3	2
11 52-305CMS	-8	-8	1	1	9	10	13	-6	-2	-3	-7
12 52-407	-3	4	-3	4	-10	5	2	9	-1	2	-9

1/ End classes of the environmental distribution are grouped to include at least ten observations in each class.

The identifiable numbers of superior and inferior genetic deviates in the populations are calculated as for percentage sucrose and are listed in Table 14. The relationship between the numbers of genetic deviates and the broad sense heritability ratios are shown in Table 15. All correlations between heritability ratios and identifiable numbers of genetic deviates are significant with the highest correlation between the identifiable number of inferior genetic deviates and heritability.

Table 14. Heritability ratios and identifiable numbers of genetic deviates for log weight per root in the 1963 population genetic study.

Population number and population	Heritability ratio	Identifiable number of genetic deviates		
		Superior	Inferior	Total
1 Polycross composite of 5 superior selections	0.479	37±6	26±5	63±7
2 Polycross composite of all selections	0.466	41±6	32±5	73±8
3 Synthetic of 5 superior selections	0.439	36±6	24±5	60±7
4 A56-3	0.489	43±6	34±6	77±8
5 Synthetic of all recurrent selections	0.446	37±6	30±5	67±7
6 Synthetic of 5 sup. recurrent selections	0.559	65±7	48±6	113±9
7 SLC 15 BB_2	0.383	33±6	20±4	53±7
8 SLC 15 BB_1	0.402	37±6	24±5	61±7

Table 15. Simple correlation coefficients between heritability ratios and identifiable numbers of genetic deviates for log weight per root in the 1963 population genetic study.

Superior		Inferior		Total	
r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$
0.87**	76	0.92**	85	0.90**	82

Tests of normality of the transformed data for the segregating populations and the pooled nonsegregating populations were made. The distribution due to the environment is not normal. Among the segregating populations four are distributed in an approximately normal manner (populations 1, 5, 7, and 8), while the other four (populations 2, 3, 4, and 6) show greater deviations from normal than would be expected by chance alone.

Bivariate frequency distributions

Bivariate frequency distributions for the 12 populations were made. Following methods of Powers et al. (6) these distributions are partitioned in the same manner in which the univariate distributions were divided. This divides each bivariate distribution into nine sections which are numbered and described as follows:

Section 1: Inferior for weight and inferior for sucrose

Section 2: Average for weight and inferior for sucrose

Section 3: Superior for weight and inferior for sucrose

Section 4: Superior for weight and average for sucrose

Section 5: Superior for weight and superior for sucrose

Section 6: Average for weight and superior for sucrose

Section 7: Inferior for weight and superior for sucrose

Section 8: Inferior for weight and average for sucrose

Section 9: Average for weight and average for sucrose

Those individuals phenotypically superior for both percentage sucrose and log weight per root appear in section 5, while phenotypically inferior individuals appear in section 1. The distributions of the F_1 hybrids and inbreds, populations 9, 10, 11, and 12, are considered to be estimates of the bivariate distribution due to environment. Their mean distribution is used for this purpose.

To avoid the problem of small numbers in certain sections, sections 4, 5, and 6 and sections 1, 2, and 8 are grouped. This grouping results in homogeneity within both the segregating and nonsegregating populations. In Table 16 the identifiable numbers of genetic deviates within these groups are listed for the eight segregating populations. These numbers result from subtracting the number of individuals due to environment from the obtained number in each group. A homogeneity chi square of the identifiable numbers of superior and inferior genetic deviates over the eight segregating populations fails to detect any difference in the ratio of superior to inferior genetic deviates. There are, however, differences in superior, inferior, and total identifiable numbers of genetic deviates for certain of the populations which are shown by the standard errors in Table 16.

Table 16. Heritability ratios and identifiable numbers of genetic deviates in sections 4, 5, and 6 (superior) and sections 1, 2, and 8 (inferior) and their total for the partitioned bivariate frequency distributions for percentage sucrose and log weight per root in the 1963 population genetic study.

Population number and population	Heritability ratio		Identifiable numbers of genetic deviates		
	Sucrose	Weight	Superior	Inferior	Total
1 Polycross composite of five sup. sel.	0.233	0.479	22 ± 5	17 ± 4	39 ± 6
2 Polycross composite of all selections	0.245	0.466	33 ± 6	28 ± 5	61 ± 7
3 Synthetic of five sup. selections	0.315	0.439	36 ± 6	34 ± 6	70 ± 8
4 A56-3	0.346	0.489	25 ± 5	28 ± 5	53 ± 7
5 Synthetic of all recurrent sel.	0.221	0.446	30 ± 5	16 ± 4	46 ± 6
6 Synthetic of five sup. recurrent sel.	0.089	0.559	40 ± 6	33 ± 6	73 ± 8
7 SLC 15 BB_2	0.308	0.383	40 ± 6	38 ± 6	78 ± 8
8 SLC 15 BB_1	0.334	0.402	35 ± 6	24 ± 5	59 ± 7

The heritability ratios in Table 16 are those previously listed in Tables 3 and 11. The multiple correlations of identifiable numbers of genetic deviates on heritability ratios, as used by Powers et al. (6), reveal no significant correlations with superior, inferior, or total number of genetic deviates. These multiple correlation coefficients are listed in Table 17. It should be noted that there is a significantly negative relationship between the heritability ratios for percentage sucrose and weight per root, r = -0.731 with 6 degrees of freedom. Effects of this relationship will be discussed later.

Table 17. Multiple correlation coefficients of heritability ratios on superior, inferior, and total identifiable numbers of genetic deviates for percentage sucrose and log weight per root in the 1963 population genetic study.

Superior		Inferior		Total	
R	$R^2(100)$	R	$R^2(100)$	R	$R^2(100)$
0.52	0.27	0.09	0.01	0.19	0.04

Heritability

From results presented in preceding sections, several estimates of heritability can be developed. Warner (9) groups methods of estimating heritability into three main classes; those based on (a) approximation of nonheritable variance from genetically uniform populations to estimate total genetic variance, (b) variance components from an analysis of variance, and (c) parent-offspring regressions.

Heritability estimates (h^2) from all phases of this study for percentage sucrose are presented in Table 18. Using nonsegregating populations as estimates of environmental variance, it is evident from the three estimates for SLC 15 BB_2 that there is considerable effect due to years. The environmental variance in 1959 and 1961 was estimated by the same two nonsegregating populations, yet the heritability ratios for the two years are considerably different. Year effect on heritability ratios estimated in this manner would appear to be appreciable.

Table 18. Heritability ratios for percentage sucrose estimated from different years and populations using three methods.

Method of estimation and population	Year 1959	1961	1963
<u>Using Nonsegregating Populations as Estimates of the Environmental Variance</u>			
SLC 15 BB_2	0.729	0.477	0.308
SLC 15 BB_1		0.531	0.334
Pooled progeny lines		0.521	
Polycross composite of five superior sel.			0.233
Polycross composite of all selections			0.245
Synthetic of five superior selections			0.315
A56-3			0.346
Synthetic of all recurrent selections			0.221
Synthetic of five superior recurrent sel.			0.089
<u>Using Analysis of Variance Components</u>			
Pooled progeny lines		0.251	
<u>Using Parent-progeny Regression</u>			
Pooled progeny lines		0.316	

All progeny lines in 1961 were pooled for a single estimate of heritability. Since there were only 100 observations in ten replications within each progeny line, heritability estimates for individual progeny lines could not be considered highly reliable. Heritability for pooled progeny lines in 1961, 0.521, is not greatly different than the parent population, SLC 15 BB_2, at 0.477; hence, the heritable variability has been changed but little by recombination of individuals phenotypically superior for both percentage sucrose and weight per root.

The slightly lower value of h^2 for SLC 15 BB_2 relative to SLC 15 BB_1 for both 1961 and 1963 is not sufficient to be of any significance. Examination of h^2 for the selected populations in 1963 indicates a general reduction in the genetic variance due to the selection and recombination practices. Their heritabilities are all significantly greater than zero except for the synthetic of five superior recurrent selections where $h^2 = 0.089$. It must be remembered that these heritability estimates are, as defined by Lush (4), broad sense estimates. The genotype functions as a unit in the individual itself; hence, an expression of all types of gene action is meant when heritability is used in the broad sense. But the genes segregate and recombine each generation into new combinations, and the effects which genes have in certain combinations may be transmitted only in part if at all. Lush (4), uses heritability in the narrow sense to describe the fraction of the differences between parents which can be expected to be recovered in their offspring. The heritability estimates in Table 18 developed from the analysis of variance and parent-progeny regression are narrow sense estimates of heritability and as such are ratios of breeding value deviations from the mean to total deviations. The analysis of variance and calculation of the components are shown in Table 19. The 33 progeny lines in 1961 are treated as half-sib families in the manner used by animal workers. In reality, a few of the individuals in each progeny line are probably full rather than half-sibs. If mating had been completely random with equal likelihood of cross and self-pollination, 1/33 or about three percent of all individuals would be full rather than half-sibs and about three percent would have resulted from self-pollination. This would increase slightly the genetic covariance of individuals within a progeny line and in turn would increase slightly the narrow sense heritability ratio estimated from covariances within progeny lines. It is not likely that there was actually three percent self-pollination. Any slight increase in the heritability estimate caused by the deviation from a strict half-sib relation can be ignored without serious consequence. The component of variance for half-sib families, or progeny lines, $\hat{\sigma}_F^2$, is the variance between the means of half-sib families and it estimates, according to Falconer (3), the phenotypic covariance of half-sibs which is 25 percent of the additive variance, plus 6.25 percent of the additive by additive component, $\frac{1}{4}V_A + \frac{1}{16}V_{AA}$. The latter term is a small proportion of the total epistatic variance and can be ignored without serious consequence. Hence, $h^2 = V_A/V_T = 4(0.154130)/2.451756 = 0.251$. No deviations due to dominance enter into this covariance between half-sibs. Dominance components enter into covariances between relatives only when they have common dominance elements, that is when two genes at a locus of an individual are identical by descent with the two genes at the same locus of its relative.

Table 19. Analysis of variance for percentage sucrose of all progeny lines in the 1961 polycross progeny test and calculation of the components of variation.1/

Source of variation	Sum of squares	df	Mean square	F value	F value at 5%	F value at 1%	Expected mean square
Half-sib families	655.2871	32	20.477722	4.04	1.52	1.79	$\sigma_w^2 + n\sigma_{fr}^2 + nr\sigma_f^2$
Replications	338.9317	9	37.659078	20.14	1.89	2.43	$\sigma_w^2 + nf\sigma_r^2$
Families X reps.	1458.6429	288	5.064732	2.71	1.19	1.28	$\sigma_w^2 + n\sigma_{fr}^2$
Residual	5552.9080	2970	1.869666				σ_w^2
Total	8005.7697	3299					$\sigma_w^2 + n\sigma_{fr}^2 + nf\sigma_r^2 + nr\sigma_f^2$

1/ Components of variance attributable to the following sources:

Half-sib families $\hat{\sigma}_f^2 = (20.477722 - 5.064732)/(10)(10) = 0.154130$

Replications $\hat{\sigma}_r^2 = (37.659078 - 1.869666)/(33)(10) = 0.108453$

Families X reps. $\hat{\sigma}_{fr}^2 = (5.064732 - 1.869666)/10 = 0.319507$

Within-plot $\hat{\sigma}_w^2 = 1.869666$

Total $\hat{\sigma}_t^2 = 2.451756$

The heritability estimate from the parent-progeny regression is derived from the relation between the 1959 sucrose percentages of the 33 parents and the means of their progeny lines in 1961. Hence, it is the regression of progeny on one parent and as such is an estimate of one-half the heritability. This represents the regression of breeding values on phenotypic values, which in this case estimates one-half the heritability in the narrow sense. This regression coefficient is 0.158 and heritability is then estimated as 0.316. This regression based on 33 parent-progeny comparisons is not likely to be as accurate as the covariance of 3300 half-sibs used to estimate $\frac{1}{4}V_A$. Hence, 0.251 is considered the best estimate of h^2 in the narrow sense.

Using the covariance between half-sibs to estimate the additive variance and the total within-plot variance of the F_1 hybrid to estimate the environmental variance, the total within-plot variance of pooled progeny lines is partitioned in Table 20 into additive genetic, nonadditive genetic, and environmental variance. The nonadditive genetic component is the sum of the dominance and interaction components. The design of this experiment does not permit the partitioning of these two components.

Table 20. Partitioning of the variance of all progeny lines for percentage sucrose in the 1961 polycross progeny test.

Component of variation	Symbol	Variance
Total within-plot	V_T	2.330346
Additive genetic	V_A	0.616520
Nonadditive genetic	$V_D + V_I$	0.597333
Environmental	V_E	1.116493

The total genetic variance amounts to 52 percent of the total variance with slightly more than half of this total genetic variance attributed to additive effects of the genes involved. It is this additive variance that is the important component since it is the chief cause of resemblance between relatives and the chief determinant of the response of the population to selection. The relatively large nonadditive genetic component provides possible evidence of genic dominance, but the relative importance of genic dominance to interallelic interaction cannot be deduced.

Heritability estimates (h^2) from all phases of the study for weight per root are presented in Table 21. Using nonsegregating populations as estimates of environmental variance, it appears from SLC 15 BB_2 that years have considerable effect on these broad sense heritability estimates. Year effects in this case could be due in large part to between row spacing. The 1961 heritabilities in the broad sense for SLC 15 BB_2 and pooled progeny lines are not demonstrably different from each other nor are they likely to be different than zero. The year effect appears to have resulted in a considerable increase in the environmental variability relative to the genetic variability. This is pointed out by an examination of the components in Table 22. Nearly all the variability in weight per root occurs within plots, $\hat{\sigma}_w^2 = 0.282553$. Hence, most of the variability is between half sibs relative to between half-sib families or progeny lines. The lack of between row competition interacting with these particular genotypes in the 1961 experiment could have been a cause for this significant increase in the within-plot variance. The components of variance in Table 23 indicate that the nonadditive genetic variance is more important than the additive genetic variance, but neither of them is of any significance relative to the large environmental variance.

Table 21. Heritability ratios for weight per root estimated from different years and populations using three methods.

Method of estimation and population	Year 1959	1961	1963[1/]
Using Nonsegregating Populations as Estimates of the Environmental Variance			
SLC 15 BB_2	0.267	0.045	0.383
SLC 15 BB_1		0.134	0.402
Pooled progeny lines		0.060	
Polycross composite of five superior sel.			0.479
Polycross composite of all selections			0.466
Synthetic of five superior selections			0.439
A56-3			0.489
Synthetic of all recurrent selections			0.446
Synthetic of five superior recurrent sel.			0.559
Using Analysis of Variance Components			
Pooled progeny lines		0.023	
Using Parent-progeny Regression			
Pooled progeny lines		0.083	

1/ Heritability estimates based on log weight per root.

Table 22. Analysis of variance for weight per root of all progeny lines in the 1961 polycross progeny test and calculation of the components of variation.1/

Source of variation	Sum of squares	df	Mean square	F value	F value at 5%	F value at 1%	Expected mean square
Half-sib families	13.146957	32	0.410842	1.65	1.52	1.79	$\sigma_w^2 + n\sigma_{fr}^2 + nr\sigma_f^2$
Replications	12.976632	9	1.441848	5.10	1.89	2.43	$\sigma_w^2 + nf\sigma_r^2$
Families X reps.	71.793443	288	0.249283	0.88	1.19	1.28	$\sigma_w^2 + n\sigma_{fr}^2$
Residual	839.181250	2970	0.282553				σ_w^2
Total	937.098282	3299					$\sigma_w^2 + n\sigma_{fr}^2 + nf\sigma_r^2 + nr\sigma_f^2$

1/ Components of variance attributable to the following sources:

Half-sib families $\hat{\sigma}_f^2 = (0.410842 - 0.249283)/(10)(10) = 0.00161559$

Replications $\hat{\sigma}_r^2 = (1.441848 - 0.282553)/(33)(10) = 0.00351302$

Families X reps. $\hat{\sigma}_{fr}^2 = (0.249283 - 0.282553)/10 = -0.00332700$

Within-plot $\hat{\sigma}_w^2 = 0.28255300$

Total $\hat{\sigma}_t^2 = 0.28435500$

Table 23. Partitioning of the variance of all progeny lines for weight per root in the 1961 polycross progeny test.

Component of variation	Symbol	Variance
Total within-plot	V_T	0.282543
Additive genetic	V_A	0.006462
Nonadditive genetic	$V_D + V_I$	0.010568
Environmental	V_E	0.265513

Examination of the heritability estimates for the selected populations in 1963, Table 21, indicates a general increase in the genetic variance relative to SLC 15 BB_2. The selection and recombination practices would seem to have increased genetic variability. The heritabilities of all selected populations are significantly greater than zero.

The heritability estimate of 0.083 for pooled progeny lines from the parent-progeny regression in Table 21 is higher than the broad sense estimate of 0.060. Actually this is impossible since the dominance and epistatic components cannot be less than zero. However, the difference is small and could easily be due to chance. In any case the relative proportion of the variance attributable to environment is very high. As in percentage sucrose, the covariance of 3300 half-sibs used as an estimate of 25 percent of the additive variance is considered more accurate than the parent-progeny regression based on 33 paired observations.

Effect of Selection for the Monogerm Character

Since SLC 15 BB_2 resulted from a critical selection for monogerm segregates in SLC 15 BB_1 and consisted initially of 753 of these monogerm segregates, the genetic constitution of SLC 15 BB_2 and SLC 15 BB_1 should be practically the same except for the monogerm character and any characters linked with it. Comparison of their means for sucrose percentage in 1961 and 1963 shows the sucrose of SLC 15 BB_2 to be higher both years, the difference being significant in 1963. This is an indication of a possible linkage between the monogerm character and higher percentage sucrose.

Examination of the means for weight per root reveals no apparent differences. SLC 15 BB_1 is slightly larger in 1961 while SLC 15 BB_2 is slightly larger in 1963, neither of the differences being significant. These data provide no indication of a linkage between the genes for the monogerm character and those for root weight.

Discussion

This discussion will encompass all phases of the study.

Theoretical Considerations

The individuals selected as parents in this study were large contributors to the genetic variance of their parent population by virtue of their being wide deviates from the population mean. If this superiority is not passed on to their progeny, it could be for any or a combination of several reasons. The parental superiority may have been due to chance alone or to a particularly favorable within-plot environment. An outstanding interallelic interaction could also have been a contributing factor. If this were the case, according to Falconer (3), less than one-fourth of this superiority, on the average, would be passed on to the progeny. Dominance conditions may also have contributed to the superiority of selected individuals. None of this superiority would be passed on to the progeny. It is only in combination with a particular type of gamete that this type of parental superiority would be realized. A most common contributor to superiority of an individual is the additive effects of its genes. Superiority of this nature should be reflected directly in the progeny.

If all variability were due to the effects of completely additive genes, there would be just one best genotype toward which mass selection would tend to move the population. This would be true whatever the starting point, but would be limited by the available resources in the gene pool. Hence, the limit to which mass selection can advance a population will have been reached when all desirable genes are fixed in the population. For characters governed by many genes the probability is very small that this limit can be reached.

The advance demonstrated by the 1961 progeny lines could be due to selection for additive gene effects and also due to the effects of superior general combining ability. The two are confounded in the experiment except as they can be differentiated by the narrow sense heritability estimate. The two can also be differentiated by comparisons of the data for the 1963 populations. The demonstrated advance is likely to have resulted from a combination of both effects.

Percentage Sucrose

In 1961 the difference in percentage sucrose between the mean for pooled progeny lines and SLC 15 BB_2 was 0.5760 ± 0.0715. This represents an advance of about four percent, *t* is 8.06 with 3898 degrees of freedom.

This advance represented by the mean of pooled progeny lines is highly significant. Population 2 in 1963, polycross composite of all selections, which as pointed out earlier is somewhat analogous to the pooled progeny lines in 1961, is not different than SLC 15 BB_2. This would indicate that some of the advance in percentage sucrose demonstrated in 1961 may have resulted from a favorable genotype by year interaction. The means for populations 5 and 6 from Table 3, resulting from recurrent selections, are the only segregating populations which significantly exceed SLC 15 BB_2. They are first generation synthetics resulting from interpollination of phenotypic selections from superior combining progeny lines. The advance represented by these populations is beyond that of the first cycle of selection. This advance indicates that sucrose percentage can continue to be improved through advanced cycles of selection. These recurrently selected populations represent a significant increase over the adapted commercial variety, population 4.

The genetic variances of populations 5 and 6 are the lowest of all eight segregating populations. Hence, the increased means have been accompanied by decreased genetic variances. The considerably reduced genetic variance of population 6 may be partly due to the fact that two of the five individuals recombined to form this population were selections from the same progeny line in 1961; hence, they were related as at least half-sibs. This relation in population 6, accompanied by increased means, reduced genetic variances, and continued improvement due to recurrent selection indicates that a considerable portion of the genetic variation and, hence, genetic improvement due to selection, may be due to additive gene effects.

Population 3 in 1963 is the only selected population resulting in a lower sucrose percentage than the parent population, SLC 15 BB_2. This first generation synthetic of five genotypes shown to be superior in the progeny test could be lower if the five genotypes were somewhat similar as regards their nonadditive gene effects. This assumes dominance and epistatic gene effects to be of major importance, which is somewhat contrary to evidence from populations 5 and 6. However, it should be pointed out that all selected populations need not necessarily exhibit the same type of genetic behavior.

The genetic gain predicted in 1959 could be attained by reproducing the genotypes represented by the identifiable genetically superior individuals. If these individuals are superior because of the additive effects of their genes, this superiority should be passed on to their progeny. The degree to which this superiority fails to be transmitted to the progeny should be an indication of the relative importance of dominance and epistatic gene effects in the identifiable genetically superior individuals. The predicted mean for percentage sucrose in 1959 was 12.13 and represents an advance of 5.4 percent. This predicted advance should be comparable

with the advance for pooled progeny lines in 1961 which is 3.8 percent. Hence, somewhat over half of the superiority of the identifiable genetic deviates appears to be due to additive gene effects. The partitioning of the genetic variance of the 33 progeny lines in Table 20 also indicates that about half the genetic variance is attributable to additive gene effects.

Since the tests of normality of the 1963 percentage sucrose data indicate that the environmental variability is not normally distributed, it follows, according to Robson and Powers (8), that the heritability ratios and identifiable numbers of genetic deviates are not equivalent and that neither can be regarded as an adequate index of the true heritability. The true heritability in this case is inestimable. This lack of equivalence is evidenced in Table 8 where for percentage sucrose there were significant correlations between the broad sense heritabilities and identifiable numbers of inferior and total identifiable numbers of genetic deviates but no relation with identifiable numbers of superior genetic deviates. Since it is the superior deviates in which the breeder is most interested, it can be concluded that for the eight segregating populations in 1963 the heritabilities as calculated are probably not the most useful index of the breeding value of the population. The identifiable numbers of genetic deviates probably provide a better breeding guide but still do not, by themselves, provide information about the breeding value of the population as described by Falconer (3). For example, if all the superior genetic deviates were superior because of interallelic interactions then most of what would be accomplished by mass selection for these epistatic effects would be undone in the first random mating generation after selection, assuming equal frequency of allels. If as is indicated in Table 20 about half of the genetic variance is due to the additive effects of genes, then the identifiable numbers of superior genetic deviates should be a fair index of the breeding value of a population, superior to the broad sense heritability ratio. As was implied above, the one thing identifiable numbers of genetic deviates does not tell the breeder is why these individuals are genetic deviates and, hence, how they should be utilized in a breeding program to capitalize on this parental superiority.

Weight per Root

The predicted mean for weight per root in 1959 was 0.717 kilograms, which represents an advance of 14 percent. The obtained advance measured by pooled progeny lines in 1961 is 6.0 percent. According to these calcutions, slightly less than half of the parental superiority is passed on to their progeny.

In considering the advance made in weight per root, from Table 9 it was noted that populations 1 and 3 in 1963 were significantly greater than

the parental material SLC 15 BB_2 (population 7), representing increases of 6.3 and 15.4 percent, respectively. Populations 2, 5, and 6 could not be demonstrated to be different from SLC 15 BB_2. Populations 1 and 3 are related as half sibs and, hence, should theoretically have a genetic correlation of 0.25. This could partially account for their parallel improvement. If the five parents leading to these two populations simulated different F_1 genotypes, then populations 1 and 3 would simulate a composite of double crosses.

Population 2, which actually represents a single generation of mass selection, shows no progress. This is evidence that mass selection is of little value in increasing the yielding capacity of a relatively adapted population. Populations 5 and 6, which are recurrent selections from progeny lines with high general combining ability, have failed to combine with each other any better than the average of SLC 15 BB_2.

Even though recurrent selection from the high performance polycross lines failed to advance weight per root, it must be recalled that percentage sucrose was significantly improved in both these populations. Hence, in these two populations resulting from recurrent selection for general combining ability, root weight has been maintained, while percentage sucrose has been improved. Population 1 which is a composite from the five high performing polycross lines is the opposite of populations 5 and 6. In this case percentage sucrose has been maintained, while root weight has been improved. Hence, populations 1, 5, and 6 should represent improvements over SLC 15 BB_2.

It is of interest to note from Table 11 that all segregating populations have larger genetic variances than SLC 15 BB_2 although only populations 4 and 6 are significantly greater. This relatively high variance for population 6 is without apparent explanation considering that two of the five parents of this population are half sibs. However, examination of the frequency distribution in Table 12 indicates that population 6 is probably trimodal, resulting in larger within plot and genetic variances. This is also reflected in the numbers of genetic deviates in Table 14 where population 6 has significantly larger identifiable numbers of both superior and inferior genetic deviates.

For log weight per root in 1963, the frequency distributions due to environment are not normally distributed. In spite of this, the correlations between identifiable numbers of genetic deviates and heritability ratios are all significant and relatively high as shown in Table 15. Therefore, these broad sense heritability ratios are quite good indicators of the identifiable numbers of genetic deviates in the 1963 populations, especially of inferior genetic deviates. As in the case of percentage sucrose, the identifiable proportion of superior genetic deviates is probably a better

indicator of the genetic potential of a population than is the broad sense heritability ratio. However, this proportion does not provide information as to the type of gene action involved. Information of this nature must come from partitioning the genetic variance, or better, from actual performance tests.

Percentage Sucrose and Weight per Root

The identifiable numbers of genetic deviates from the 1963 bivariate frequency distributions of each population grouped into superior, inferior, and total are listed in Table 16. The multiple correlations of the broad sense heritability ratios with the identifiable numbers of genetic deviates, as shown in Table 17, fail to detect any significant relation. This is contrary to results found by Powers et al. (6), where they found significant multiple correlations with both identifiable numbers of superior and total identifiable numbers of genetic deviates. This was with an entirely different group of populations, of course, and they did not show the heritability ratios for the two characters to be related. The low multiple correlations in Table 17 are probably due in part to the lack of normality of the bivariate distributions. Although these bivariate distributions are not tested directly for normality, the joint distribution of two anormal univariate distributions should itself be anormal.

Under conditions of bivariate normality, the multiple correlation coefficient would serve as an index of the predictive value of the two heritability ratios as regards the number of genetic deviates. In the case at hand, little information about the identifiable number of doubly superior individuals would be gained by examination of the heritability ratios for weight and for sucrose. In this special case, this is partly due to the negative relationship between the heritability ratios for weight and sucrose, $r = -0.731$. Hence, the identifiable number of superior genetic deviates tends to maximize when the two heritability ratios are near their mean for all populations.

A more easily interpretable indicator of the relation of identifiable numbers of genetic deviates and heritability ratios, h^2_s and h^2_w, might be the simple correlation of the numbers of genetic deviates on $h^2_s h^2_w$ or $\sqrt{h^2_s h^2_w}$. $h^2_s h^2_w$ would be similar to a joint probability, or the product of two independent probabilities. $\sqrt{h^2_s h^2_w}$ would be the geometric mean of the heritabilities for sucrose and weight. Correlations of the index $h^2_s h^2_w$ with superior, inferior, and total identifiable numbers of genetic deviates in the 1963 data are respectively -0.42, 0.01, and -0.20. These same correlations with the index $\sqrt{h^2_s h^2_w}$ are -0.43, -0.03, and -0.23. None of these correlations are significant, but it should be noted that they tend to be negative. This is further evidence that except under conditions of normality more information about the breeding potential of a population is to

be gained by examination of partitioned frequency distributions than by a study of the heritability ratios.

Components of Variance

In the development of the components of variance in this study, the use of an estimate of genetic variance contingent on measuring the variance of nonsegregating populations as an approximation of environmental variance is considered usable for percentage sucrose and log weight per root.

In finding the total genetic variance by subtracting the variance of a homozygous line or an estimate of the environmental variance, the remainder is considered a measure of the deviations due to the additive gene effects as well as all of the dominance and epistatic effects.

The calculation of variance components in Tables 19 and 22 is an attempt to partition this total genetic component into additive and non-additive components. The analysis is essentially a determination of the covariance of half-sibs which is on an average, according to Falconer (3), one-fourth of the additive genetic variance and one-sixteenth of the additive by additive epistatic variance. Ignoring the small portion of the epistatic variance, this provides the estimate of the additive component. This estimate could be biased upward by the linkage of genes controlling the character of interest. Linkage would result in an increase in the covariance of half-sibs; the closer the linkage, the greater the increase. There is no basis for determining whether or not linkage exists in the populations under study, but its possibility should be borne in mind.

Breeding Considerations

A study of the means, variances, and partitioned frequency distributions for percentage sucrose indicates that the narrow sense heritability estimate of 0.251 for pooled progeny lines in 1961 is at least reasonable. Together, then, they indicate that genetic improvement of percentage sucrose should be possible with SLC 15 BB_2 through both additive and nonadditive gene effects. Hence, the greatest improvement should be achieved through the use of breeding methods designed to capitalize on both types of gene action. Recurrent or reciprocal recurrent selection should provide the best scheme for improvement of percentage sucrose. However, considerable progress should be possible, using various mass selection schemes.

Unfortunately the 1961 estimates of genetic variance for weight per root are too low to be of much value in the study. As pointed out previously, they are considered to have resulted from over-estimation of the environmental variance. However, considerations of means, variances, partitioned frequency distributions, and heritability ratios over all years

lead to the conclusion that additive gene effects are of less importance, relative to those for percentage sucrose, than nonadditive gene effects. Breeding methods like recurrent selection and reciprocal recurrent selection should offer the greatest promise for advancement of root weight.

Based on the apparent importance of nonadditive gene effects, it appears that synthetic combinations provide a means of more immediate improvement for yield of sugar but theoretically cannot provide the ultimate in genetic advance.

The desirability of large populations in any improvement program cannot be overemphasized. The approximately 9,600 individuals screened for superior individuals are for this population a bare minimum. It will be recalled that only two individuals per 10,000 were expected to have a probability of greater than 0.999 for being genetically superior for both percentage sucrose and weight of root.

That there are genetically superior individuals segregating in the population indicates that there are rare gametes which in combination with other rare gametes produce a superior zygote. The data of this study indicate that these zygotes result partially from high combining ability. Since the species cannot be readily asexually propagated, the constant reproduction of these superior gametes can come only from homozygous lines. Hence, it will probably be necessary to fix the genotype by inbreeding, which produces these superior gametes, in order to reproduce them. This means the development of a program not different than that developed in corn breeding. However, the additive effects of genes in these populations should not be discounted, particularly for percentage sucrose. The development of populations on which recurrent or reciprocal recurrent selection and ultimately inbreeding can be practiced may be effected through the isolation and crossing of genetically superior individuals. It is possible that such a breeding scheme could reduce considerably the amount of effort involved in a recurrent or reciprocal recurrent selection program.

Summary

The purpose of the study is to obtain fundamental information on methods of breeding sugarbeets. Mass selection from small units, polycross performance, recurrent selection for general combining ability, and synthetic combinations are used in an attempt to modify the population genotypes with respect to improved weight per root and percentage sucrose. The partitioning method and components of variance are used in interpreting and evaluating the effects of the breeding practices.

The experiment was conducted over six years. Using the small unit method of mass selection, selections were made from a broad based monogerm sugar beet population with these selections being polycrossed and progeny tested. Recurrent selections for general combining ability were made in the polycross progeny test. Five different synthetic or composite populations were developed and compared with parental and various other populations.

For percentage sucrose, the two synthetic populations developed from recurrent selections have significantly higher means than the parental material from which the initial selections were made. The synthetic from asexual propagations of the initial selections is significantly lower. The two populations of composited polycrossed seed can not be shown to be different. The two synthetic populations from recurrent selections which have the highest means have at the same time the lowest genetic variances.

As regards weight per root, the composite of polycrossed seed from five plants and the synthetic from asexual propagations are higher than the initial parental population, while the other three populations are not significantly different. Considering both characters, it appears that the polycross composite of five superior selections and the two synthetics of recurrent selections represent improvements over the parental population.

The identifiable proportions of genetic deviates are determined using the partitioning method. From the partitioned bivariate frequency distributions, it appears that except under conditions of normality more information about the breeding potential of a population is to be gained by examination of the identifiable numbers of genetic deviates than by a study of the heritability ratios.

Components of variance calculated from a half-sib covariance analysis indicate that for percentage sucrose additive gene effects are equally as important as dominance and epistatic effects. For weight per root there is some evidence that dominance and epistatic effects are of greater importance than additive gene effects. Indications are that the greatest improvement in both weight per root and percentage sucrose in sugarbeets should be achieved through the use of breeding methods designed to capitalize on both types of gene action.

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PART XI

EVALUATION OF BASIC BREEDING MATERIAL AND VARIETIES OF SUGARBEETS SUITABLE FOR THE GREAT LAKES REGION

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BREEDING FOR LEAF SPOT AND BLACK ROOT RESISTANCE[1/]

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Cooperation:

Farmers and Manufacturers Beet Sugar Association
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Canada and Dominion Sugar Company, Ltd.
Michigan Sugar Company
Michigan Agricultural Experiment Station
Monitor Sugar Division
Northern Ohio Sugar Company
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EVALUATION OF SUGARBEET VARIETIES AND BASIC BREEDING MATERIAL SUITABLE FOR THE GREAT LAKES REGION

The evaluation program was continued in 1965 on a cooperative basis as it has been for several years. Wind damage, emergence and other problems affected about half the variety tests this year. Incomplete data were taken from some tests, while others were completely abandoned. The report is divided into two sections: 1) regional field tests of advanced hybrids that are candidates for growers use; 2) miscellaneous hybrids and open-pollinated material.

Section 1. Regional Field Tests of Hybrids

In 1965 regional field tests were composed of seven hybrids and 5822. These were tested in an 8 x 8 Latin Square design. The hybrids were pollinated by either SP5822-0 or SP6322-0. Two hybrids, SL(126x128)ms X SP5822-0 and SL(129x133)ms X SP5822-0, and SP5822-0 are repeats from last year's tests. This is the first year for SP6322-0 as a pollinator in the regional field tests. A direct comparison can be made between SP5822-0 and SP6322-0 with SL(129x133)ms as the female parent.

All tests were examined in mid-September and harvest data were taken only from those tests judged to be uniform enough for reliable results.

QUALITY - Pounds of recoverable sugar per ton:
The relative results for the 1965 data are different from the 1964 data for the three common varieties over the two years. In 1964 SP5822-0 was higher than the two common hybrids; in some cases significantly so. Whereas in 1965 SP5822-0 was lower than the two common hybrids, and in some cases this difference was significant. The hybrid (SP6121xEL31)ms X SP6322-0 gave the most consistent high quality response.

QUANTITY - Tons of roots per acre:
The hybrid SL(129x133)ms X SP6322-0 gave a higher yield response than (SP6121xEL31)ms X SP6322-0, the next highest overall contender. The hybrid with SP6322-0 pollinator on SL(129x133)ms resulted in higher yields than the one with SP5822-0 on the same female. The difference was significant only at Sebewaing, however.

PRODUCTION - Pounds of recoverable sugar per acre:
The best overall performance was that of hybrid SL(129x133)ms X SP6322-0 followed by (SP6121xEL31)ms X SP6322-0 and SL(129x133)ms X SP5822-0.

DISEASE RESISTANCE - Leaf spot readings:
SP5822-0 showed more resistance than the hybrids in the tests. The SL females gave less resistance to their hybrids than did the Eastern numbers. The Utah - Idaho seed number 3561 contributed resistance to the single cross female SP6121x3561ms. It should be pointed out that the Ottawa, Ohio, test from which the leaf spot data were taken, is different from the Hamler, Ohio, test where the harvest data were taken (and leaf spot did not occur).

1965 average Leaf Spot ratings on varieties in 8 x 8 test. Summary of those trials where ratings were possible.

Varieties	Ontario Ridgetown 9-15	Ontario Chatham 9-15	Ohio Ottawa 9-14	Ohio Ottawa 10-11
SL(126x128)msXSP5822-0	3.6	4.0	3.6	4.8
SL(129x133)msXSP5822-0	3.3	3.9	3.8	5.0
SL(126x129)msXSP6322-0	3.1	3.9		
SL126XSP5460			3.6	5.0
SL(129x133)msXSP6322-0	3.1	3.9	3.3	4.6
(SP6121xEL31)msXSP6322-0	2.7	2.9	2.4	3.4
(SP6121xEL34)msXSP5822-0	2.7	2.9	2.5	4.0
(SP6121x3561)msXSP6322-0	2.3	2.6	1.6	3.5
SP5822-0	2.1	2.0	1.4	3.3
General Mean	2.88	3.25	2.77	4.20
S. E. Var. Mean	.13	.23	.21	.13
Above as % Gen. Mean	4.5	7.1	7.6	3.0
LSD 5% Point	0.4	0.7	0.6	0.4

Correlations Between Readings

	Chatham 9-15	Ottawa 9-14	Ottawa 10-11
Ridgetown (9-15)	.95	.97	.91
Chatham (9-15)		.97	.94
Ottawa (9-14)			.95

Consolidated results of 1965 8 X 8 Latin Square tests in Michigan, Ontario, and Ohio. All data except Beets/100 feet of row and Leaf Spot in percent of General Mean.

Variety		Percent of General Mean: Recov. Sugar per A.[a]	Roots per Acre	Sugar per Ton	Sucrose	Purity[b]	Actual: Beets per 100'	Leaf Spot[c]
SL(126x128)msXSP5822-0	S*	98.9	102.6	96.4	97.6	99.4	91	
	M	92.4	90.4	102.2	100.3	101.0	82	
	C	83.4	86.8	96.6	98.6	99.0	44	4.0
	H	98.1	100.1	98.3	98.7	99.8	104	
SL(129x133)msXSP5822-0	S	104.9	104.2	99.9	99.7	100.1	103	
	M	106.1	105.9	100.3	100.6	99.9	104	
	C	109.2	104.7	104.3	103.4	100.5	94	3.9
	H	98.0	96.7	101.2	100.6	100.3	112	
SL(126x129)msXSP6322-0	S	105.6	102.0	103.5	102.0	100.8	97	
	M	98.7	100.1	98.7	99.4	99.6	96	
	C	101.6	96.3	105.5	103.5	101.0	71	3.9
SL126xSP5460-0	H	101.6	100.4	101.2	100.2	100.6	115	
SL(129x133)msXSP6322-0	S	113.7	116.2	98.4	98.7	99.8	102	
	M	111.8	109.4	102.4	101.9	100.3	100	
	C	114.4	110.4	104.0	102.9	100.5	96	3.9
	H	107.5	108.2	99.3	99.5	99.9	116	
(SP6121xEL31)msXSP6322-0	S	103.2	100.0	103.2	102.7	100.3	103	
	M	107.2	103.1	104.0	103.4	100.3	101	
	C	109.4	107.2	102.3	101.7	100.3	83	2.9
	H	106.0	103.6	102.3	102.4	99.9	119	
(SP6121x[illegible]L34)msXSP5822-0	S	90.3	90.8	99.3	100.0	99.7	99	
	M	95.9	95.8	100.3	100.4	100.0	98	
	C	95.1	98.9	96.3	97.4	99.4	69	2.9
	H	95.5	94.8	100.7	101.3	99.7	106	
(SP6121x3561)msXSP6322-0	S	94.6	98.2	96.5	96.7	99.9	101	
	M	101.3	102.6	98.6	98.7	100.0	102	
	C	103.4	105.9	97.7	97.6	100.1	68	2.6
	H	95.7	97.4	98.3	98.0	100.1	116	
SP5822-0	S	88.8	86.1	102.9	102.7	100.1	100	
	M	86.7	92.7	93.4	95.4	99.0	100	
	C	83.6	89.7	93.3	95.0	99.1	51	2.0
	H	97.6	98.9	98.6	99.2	99.7	112	
Percent LSD 5% level	S	12.5	10.4	6.2NS	5.3NS	1.1NS	4	
	M	6.5	4.9	5.0	3.3	1.1	7	
	C	11.5	11.3	5.5	3.8	1.7NS	13	0.7
	H	14.5NS	14.6NS	4.4NS	3.5NS	0.7NS	NS	
General Mean (Actual)	S	4640	19.2	241.8	13.29	94.94	100	
	M	4902	20.3	241.4	13.74	93.28	98	
	C	5983	24.2	247.1	14.13	93.10	72	3.25
	H	6941	23.7	293.5	15.94	95.53	113	

* S = Sebewaing, Mich.; M = Marlette, Mich.,; C = Chatham, Ontario; H = Hamler, Ohio

Standard footnotes a, b., and c. on page 343.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Harold Gremel farm, Sebewaing, Michigan

Cooperation: F&M Beet Sugar Association - Michigan Sugar Company

Date of Planting: April 30, 1965

Date of Harvest: November 8, 1965

Experimental Design: 8 x 8 Latin Square

Size of Plots: 4 Rows 28" wide and 30 feet long

Harvested Area per Plot for Root Yield: 4 Rows - 28 ft. long

Samples for Sucrose Determination: One 10 beet sample was gathered from competitive beets before plots were harvested

Stand Counts: Stands averaged 110% throughout the test

Recent Field History: 1962 Beans - 250# 6-24-12
1963 Corn - 250# 6-24-12
1964 Beans - 250# 6-24-12

Fertilization of Beet Crop: 600# 8-32-16 plus Bo plus Mn at planting and 45# N sidedressed

Black Root Exposure: Slight

Leaf Spot Exposure:

Other Diseases and Pests: None

Soil and Seasonal Conditions: Seed bed moist at planting - less than normal rainfall throughout May, June July and August-September to harvest heavier precipitation

Reliability of Test: Excellent

Cooperator: F & M Beet Sugar Association-Mich. Sugar Co. Year: 1965

Location: Harold Gremel Farm, Sebewaing, Michigan Exp. 1

8 X 8 Latin Square

Variety	Recov. Sugar per A.[a] Lbs.	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Purity[b] %	Beets per 100' No.	Leaf Spot[c]
SL(126x128)msXSP5822-0	4589	19.7	233.0	12.98	94.33	91	
SL(129x133)msXSP5822-0	4867	20.0	241.4	13.25	95.03	103	
SL(126x129)msXSP6322-0	4898	19.6	250.2	13.56	95.69	97	
SL(129x133)msXSP6322-0	5274	22.3	237.8	13.12	94.72	102	
(SP6121xEL31)msXSP6322-0	4790	19.2	249.6	13.64	95.26	103	
(SP6121xEL34)msXSP5822-0	4192	17.4	240.2	13.29	94.60	99	
(SP6121x3561)msXSP6322-0	4389	18.9	233.3	12.85	94.87	101	
SP5822-0	4122	16.5	248.7	13.65	95.01	100	
General Mean	4640	19.2	241.8	13.29	94.94	100	
S. E. Var. Mean	203	0.71	5.30	0.245	0.303	1.5	
Above as % Gen. Mean	4.4	3.7	2.2	1.8	0.3	1.5	
LSD 5% Point	579	2.0	N.S.	N.S.	N.S.	4	

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100'	Leaf Spot
Between Rows	7	3,053,992	45.55	388.79	0.9514	0.8829	138	
Between Columns	7	680,262	8.69	508.63	0.8505	3.5246	78	
Between Varieties	7	1,231,000	24.14	397.65	0.7421	1.3994	134	
Remainder (Error)	42	329,171	4.01	224.32	0.4814	0.7361	19	
Total	63							
Calculated F. Value		3.74**	6.02**	N.S.	N.S.	N.S.	7.05**	

Standard Footnotes a., b., and c. on page 343.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Henry Miller farm, Marlette, Michigan

Cooperation: F&M Beet Sugar Association - Michigan Sugar Company

Date of Planting: May 14, 1965

Date of Harvest: October 20, 1965

Experimental Design: 8 x 8 Latin Square

Size of Plots: 4 Rows 28" wide and 30' long

Harvested Area per Plot for Root Yield: 4 Rows - 30' long

Samples for Sucrose Determination: One 10 beet sample was gathered from competitive beets before plots were harvested

Stand Counts: Stands averaged 110% over the whole test

Recent Field History: 1963 - Beets Plowed Down Rye - 500# 6-24-12
1964 - Corn - 250# 50# N.

Fertilization of Beet Crop: 1965 - Beets Plowed Down Rye
300# 6-24-12 Broadcast
325# 6-24-12 At planting time
plus 45# Actual N. Sidedressed

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests: Lygus infestation - sprayed with Malathion

Soil and Seasonal Conditions: Very dry after planting through August then heavy rain was encountered until harvest

Reliability of Test: Excellent

Cooperator: F & M Beet Sugar Association Year: 1965

Location: Henry Miller farm, Marlette, Michigan Exp.

8 x 8 Latin Square

Variety	Recov. Sugar per A.[a] Lbs.	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Purity[b] %	Beets per 100' No.	Leaf Spot[c]
SL(126x128)msXSP5822-0	4529	18.4	246.8	13.78	94.23	82	
SL(129x133)msXSP5822-0	5199	21.5	242.1	13.82	93.15	104	
SL(126x129)msXSP6322-0	4839	20.3	238.2	13.66	92.93	96	
SL(129x133)msXSP6322-0	5477	22.2	247.2	13.99	93.53	100	
(SP6121xEL31)msXSP6322-0	5255	20.9	251.2	14.21	93.58	101	
(SP6121xEL34)msXSP5822-0	4698	19.5	242.2	13.79	93.24	98	
(SP6121x3561)msXSP6322-0	4967	20.8	238.1	13.56	93.24	102	
SP5822-0	4248	18.8	225.6	13.11	92.35	100	
General Mean	4902	20.3	241.4	13.74	93.28	98	
S. E. Var. Mean	112	0.34	4.22	0.160	0.34	2.4	
Above as % Gen. Mean	2.3	1.7	1.7	1.2	0.4	2.4	
LSD 5% Point	320	1.0	12.0	0.46	0.98	7	

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100'	Leaf Spot
Between Rows	7	363,357	1.45	940.03	1.2529	4.7233	115	
Between Columns	7	220,742	3.56	652.82	1.0968	2.1470	115	
Between Varieties	7	1,325,643	14.28	491.96	0.8369	2.3550	385	
Remainder (Error)	42	100,947	0.90	142.69	0.2136	0.9451	45	
Total	63							
Calculated F. Value		13.13**	15.87**	3.45**	3.92**	2.49**	8.56**	

Standard Footnotes a., b., and c. on page 343.

AGRONOMIC EVALUATION TEST

Conducted by: C. E. Broadwell

Location: Canada & Dominion Sugar Co. Ltd., Dover Farm

Cooperation: Canada & Dominion Sugar Co. Ltd.

Date of Planting: May 3, 1965

Date of Harvest: October 5, 1965

Experimental Design: 8 x 8 Latin Square

Size of Plots: 4 Rows - 24" wide - 30' long

Harvested Area per Plot for Root Yield: 4 Rows - 28' long

Samples for Sucrose Determination: One 10 beet sample from each plot

Stand Counts: Counted when harvested

Recent Field History:

Fertilization of Beet Crop: 700# - 5-20-20 at planting time
56# N Plowed down on corn stalks

Black Root Exposure: Slight

Leaf Spot Exposure: Medium

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist soil conditions at planting and adequate moisture through growing season

Reliability of Test: Good

Cooperator: C & D Sugar Co., Ltd.,F & M Beet Sugar Association Year 1965

Location: C & D Dover Farm, Chatham, Ontario Exp. ______

8 x 8 Latin Square

Variety	Recov. Sugar per A.[a]	Roots per Acre	Sugar per Ton	Sucrose	Purity[b]	Beets per 100'	Leaf Spot[c]
SL(126x128)msXSP5822-0	4989	21.0	238.7	13.93	92.18	44	4.0
SL(129x133)msXSP5822-0	6531	25.3	257.8	14.60	93.54	94	3.9
SL(126x129)msXSP6322-0	6079	23.3	260.6	14.61	93.98	71	3.9
SL(129x133)msXSP6322-0	6843	26.7	257.0	14.54	93.58	96	3.9
(SP6121XEL31)msXSP6322-0	6545	25.9	252.7	14.36	93.39	83	2.9
(SP6121xEL34)msXSP5822-0	5687	23.9	237.9	13.75	92.58	69	2.9
(SP6121x3561)msXSP6322-0	6188	25.6	241.5	13.79	93.22	68	2.6
SP5822-0	4999	21.7	230.6	13.43	92.29	51	2.0
General Mean	5983	24.2	247.1	14.13	93.10	72	3.25
S. E. Var. Mean	241	0.957	4.74	0.190	0.54	4.6	.23
Above as % Gen. Mean	4.0	4.0	1.91	1.34	0.5	6.4	7.1
LSD 5% Point	688	2.7	13.5	0.54	N.S.	13	0.7

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100'	Leaf Spot
Between Rows	7	1,558,591	18.08	1045.82	2.0925	3.0558	131	.71
Between Columns	7	1,431,296	14.62	385.53	1.0864	1,2703	341	.43
Between Varieties	7	3,945,962	34.11	1012.64	1,6850	3.5038	2770	4.57
Remainder (Error)	42	465,681	7.33	179.73	.2908	2.3642	170	.43
Total	63							
Calculated F. Value		8.47**	4.65**	5.63**	5.79**	N.S.	16.29**	10.63**

Standard Footnotes a., b., and c. on page 343.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Pete Meyer farm - Hamler, Ohio

Cooperation: F&M Beet Sugar Association - Buckeye Sugars, Inc.

Date of Planting: May 1, 1965

Date of Harvest: November 4, 1966

Experimental Design: 8 x 8 Latin Square

Size of Plots: 4 Rows 28" wide and 30 ft. long

Harvested Area per Plot for Root Yield: 4 Rows 28 ft. long

Samples for Sucrose Determination: One 10 beet sample was gathered from competitive beets before plots were harvested.

Stand Counts: Stands averaged 122% throughout the test

Recent Field History: 1962 Clover
1963 Corn 300# 5-20-20
1964 Tomatoes 800# 5-20-20

Fertilization of Beet Crop: 275# 6-24-12 Broadcast plus 80# Actual N sidedressed

Black Root Exposure: Slight

Leaf Spot Exposure: Slight

Other Diseases and Pests: None

Soil and Seasonal Conditions: Dry at planting but above normal rainfall throughout remainder of growing season

Reliability of Test: Good

Cooperator: F & M Beet Sugar Association-Buckeye Sugar Year: 1965

Location: Pete Meyer Farm, Hamler, Ohio Exp.

8 X 8 Latin Square - 5 replications harvested and analyzed

Variety	Recov. Sugar per A.[a] Lbs.	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Purity[b] %	Beets per 100' No.	Leaf Spot[c]
SL(126x128)msXSP5822-0	6811	23.7	288.4	15.74	95.30	104	
SL(129x133)msXSP5822-0	6800	22.9	297.1	16.04	95.84	112	
SL126xSP5460-0	7055 3	23.8	297.0	15.97	96.06	115	
SL(129x133)msXSP6322-0	7460 1	25.6	291.5	15.86	95.46	116	
(SP6121xEL31)msXSP6322-0	7359 2	24.5	300.3	16.33	95.47	119	
(SP6121xEL34)msXSP5822-0	6628	22.4	295.6	16.15	95.26	106	
(SP6121x3561)msXSP6322-0	6642	23.1	288.4	15.63	95.66	116	
SP5822-0	6777	23.4	289.4	15.82	95.22	112	
General Mean	6941	23.7	293.5	15.94	95.53	113	
S. E. Var. Mean	347	1.20	4.04	0.194	0.225	4.4	
Above as % Gen. Mean	5.0	5.1	1.4	1.2	0.2	3.9	
LSD 5% Point	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	

Randomized Complete Block Analysis Variance Table

Source of Variation	D/F	Mean Squares: Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100'	Leaf Spot
Replications	4	314,844	7.23	145.70	0.1632	1.0708	269	
Varieties	7	505,673	5.02	106.11	0.2600	0.4468	136	
Repl. X Var.	28	602,621	7.20	81.60	0.1872	0.2521	98	
Total	39							
Calculated F. Value		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	

Standard Footnotes [a], [b], and [c] on page 343.

AGRONOMIC EVALUATION TEST

Conducted by: A. McClearin

Location: Western Ontario Agricultural School, Ridgetown, Ont.

Cooperation: Canada & Dominion Sugar Co. Ltd.'

Date of Planting: April 30, 1965

Date of Harvest: October 11, 1965

Experimental Design:

Size of Plots: 3 Rows - 24" wide - 20' long

Harvested Area per Plot for Root Yield: 1 Row - 16' long

Samples for Sucrose Determination: One 10 beet sample from each plot

Stand Counts: Counted when harvested

Recent Field History: 1963 - Oats 3-11-11 @ 1100# per acre
1964 - Corn 14-7-7 @ 1400# per acre -
Muriate of potash @ 650# per acre

Fertilization of Beet Crop: 1000# 14-7-7 Broadcast per acre

Black Root Exposure: None

Leaf Spot Exposure: Slight

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist Seed Bed with dry and cool growing season

Reliability of Test: Good

F & M SUGAR BEET VARIETY TRIAL - 1965

W.O.A.S. RIDGETOWN

Variety	Tons/Acre Roots	% Sugar	Clear Juice Purity	Tons/Acre Sugar	Tons/Acre Extractable Sugar
SL(126x128)MS x SP5822-0	20.13	14.1	92.39	2.85	2.40
SL(129x133)MS x SP5822-0	22.17	14.3	92.76	3.15	2.68
(126x129) x 6322-0	21.68	14.0	92.85	3.04	2.59
(129x133) x 6322-0	22.17	14.6	92.29	3.22	2.69
6121xEL61G1 x 6322-0	23.92	14.2	91.93	3.40	2.83
6121 x EL61G4 x 5822-0	21.10	14.3	91.75	3.03	2.52
6121 x 3561 x 6322-0	21.10	13.7	92.15	2.89	2.41
SP5822-0	24.11	14.6	92.32	3.52	2.96
L.S.D. @ 5%	N.S.			N.S.	
C.V.	14.3%			14.4%	

Planting date: April 30, 1965

Plot size: 3 rows x 20' (1 row x 16' harvested)

Row width: 24"

Fertilizer: 14-7-7 @ 1000 lbs./acre

Previous crop: 1964 - Oats - 3-11-11 @ 1100 lbs./acre
and fertilizer: 1963 - Corn - 14-7-7 @ 1400 lbs./acre
- Muriate of Potash @ 650 lbs./acre

Harvest date: October 11, 1965

Standard Footnotes for all Experiments with F. & M. as a Cooperator:

a) Calculated according to Great Western formula rearranged as follows: RC = TA X 2000 X %S - FL X P_K

RC is the calculated recoverable sugar.
TA is the yield of roots in tons per acre.
S is sucrose.
FL is factory loss (we used 0.30%)
P_K is 1 - (MP X 100 - CJP / 100 - MP X CJP). This factor is constant for any given CJP (clear juice purity) if the MP (molasses purity) is held constant. We used 62.5% MP for all calculations.

b) Clear Juice Apparent Purity determinations were made following procedures worked out by M. G. Frakes of Michigan Sugar Co. These values approximate the thin juice purities obtained in the factory.

c) Rating scale: 0 = no evidence of disease; 10 = complete necrosis due to leaf spot.

Section 2. Miscellaneous Hybrids and Open-Pollinated Material

Candidates were divided into two groups. Experiment 40-1 contained hybrids made at Fort Collins and East Lansing. Experiment 40-2 was composed of hybrids obtained through the F & M and open-pollinated material from Beltsville. Experiment 40-1 was planted with six replications each, while there was seed enough for only two replications each of experiment 40-2. With seed for just two locations, the tests were placed in Ohio and Ontario to increase the chances of a good evaluation for leaf spot. Both tests were planted in the same field on the Willard Jones farm near Ottawa, Ohio. They were also planted in the same field on the Canada and Dominion Sugar Company's Dover farm near Chatham, Ontario.

Stands were less than perfect in both locations. Leaf spot ratings were made in both tests. Only selected plots were harvested. The data is reported as average performance with anywhere from two to six plots making the average in the 40-1 test. Only the leaf spot data is given a detailed study.

Leaf Spot

The varieties in the 40-1 test were evaluated for leaf spot resistance at Beltsville, Maryland; East Lansing, Michigan; Ottawa, Ohio; and Chatham, Ontario. Hybrids within the test were examined in three different male by female by location analyses. In all cases there was a significant male by location interaction as well as a significant female by location interaction. The male by female interaction across all locations was not significant.

Leaf spot ratings were received from Fort Collins, Colorado, for 17 of the above 40 varieties. Correlations in all possible combinations were made between stations for the average ratings given at each of the five locations. All combinations with the Fort Collins data were on the basis of 17 varieties, whereas all other combinations were on the basis of 40 varieties. The correlations were as follows:

	Beltsville	East Lansing	Ottawa	Chatham
Fort Collins	.75	.78	.78	.78
Beltsville		.28	.71	.58
East Lansing			.51	.56
Ottawa				.76

There was no universally best hybrid in leaf spot resistance at all locations. The interactions and correlations indicate trials must be made in the area of intended production to determine the highest resistance for that area. These data do not indicate whether strains of the pathogen or environmental effects on the host-pathogen relationship are involved.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Willard Jones farm, Ottawa, Ohio

Cooperation: F&M Beet Sugar Association - Buckeye Sugars, Inc.

Date of Planting: May 3, 1965

Date of Harvest: November 2, 1965

Experimental Design: Randomized Block

Size of Plots: 1 Row 100 ft. long

Harvested Area per Plot for Root Yield: 1 Row 98 ft. long

Samples for Sucrose Determination: 10 beet sample from competitive beets before harvest

Stand Counts:

Recent Field History: 1962 Corn - 300# 5-20-20
1963 Sugar Beets - 450# 8-32-16
1964 Soy Beans

Fertilization of Beet Crop: 450# 8-32-16 plus Mn plowed down
80# N sidedressed

Black Root Exposure: Slight

Leaf Spot Exposure: Slight

Other Diseases and Pests: None

Soil and Seasonal Conditions: Dry soil conditions at planting and continued until mid-growing season

Reliability of Test: Fair

1965 **Average Leaf Spot Ratings on Varieties in 40-1 Test by Location and Dates**

Varieties		Fort Collins	Belts.	East Lansing	Ohio	Canada
		9/1	9/4	9/24	10/11	9/15
FC(502/2x503)	XSP5822-0		3.3	2.8	1.8	1.7
"	XSP59B18-0		3.8	3.0	1.8	2.2
"	XSP621160-00		3.0	3.2	1.6	1.7
"	X02 clone	2.3	4.3	3.2	2.0	2.2
"	XSP61151-0		3.7	3.2	2.1	1.8
FC502/2xSP581194s1	XSP5822-0		3.0	2.5	1.5	2.0
"	XSP59B18-0		3.7	2.5	1.9	2.5
"	XSP621160-00		3.0	2.2	1.8	2.0
FC(502/2x504)	XSP5822-0		2.3	2.8	1.7	1.0
"	XSP59B18-0		3.3	2.8	1.9	1.7
"	XSP621160-00		2.3	3.0	1.7	1.5
SP581194s1xFC504	XSP5822-0		2.3	2.7	2.0	2.0
"	XSP59B18-0		3.7	2.2	2.3	2.0
"	XSP621160-00		2.7	2.8	2.1	2.0
SP602009s1cms	XSP5822-0		3.3	2.7	2.3	2.3
"	XSP59B18-0		4.7	2.3	2.5	2.2
FC504	XSP5822-0		3.0	3.3	1.8	1.5
"	XSP59B18-0		3.0	3.3	2.1	2.0
FC502	X02 clone	2.3	4.0	2.2	1.9	2.3
"	XSP61151-0	1.4	3.3	1.8	1.8	2.2
SL133xFC501	X02 clone	2.2	4.3	2.5	2.3	2.8
"	XSP61151-0	1.4	3.3	2.5	2.2	2.3
"	XSP623259-04n		3.7	2.8	2.2	3.0
SL(126x128)	X02 clone	4.3	5.0	3.8	3.1	3.3
"	XSP61151-0	3.8	4.7	3.7	3.3	3.3
SL(126x129)	X02 clone	4.7	5.7	4.2	3.1	3.3
"	XSP61151-0	3.7	4.3	3.7	2.3	2.8
(SP6121x3561)3561	X02 clone	3.0	4.3	3.3	2.3	2.8
"	XSP61151-0	1.3	3.0	2.8	1.8	2.0
SP581194s1cms	XSP59B18-0		3.3	2.2	2.3	2.2
"	X02 clone	2.4	4.0	2.0	2.0	1.7
FC503	XSP59B18-0		4.7	3.0	2.1	1.8
"	X02 clone	2.6	5.0	2.7	2.1	2.3
SP6121xEL31	X02 clone	2.4	3.7	3.2	2.5	2.7
"	XSP623259-04n	3.5	3.3	4.2	2.0	2.8
(SL133x2161)x1861	X02 clone		5.0	3.5	3.0	3.0
sib population of	02 clone	3.3	5.0	2.5	2.8	2.2
" " "	SP61151-0	1.8	4.0	2.7	2.1	1.8
" " "	SP623259-04n		3.3	3.3	2.1	3.0
SL(129x133)	XSP5822-0		4.0	4.5	3.2	3.7
General Mean		3.0	3.7	2.9	2.3	2.3

Consolidated results of 1965 40-1 test in Ohio and Canada. Data, except Leaf Spot, is presented in percent of General Mean.

Varieties		Actual Leaf Spot[c.]		Percent of General Mean			
				Sucrose		Purity[b.]	
		Ohio	Canada	Ohio	Canada	Ohio	Canada
FC(502/2x503)	XSP5822-0	1.8	1.7				
"	XSP59B18-0	1.8	2.2				
"	XSP621160-0	1.6	1.7				
"	X02 clone	2.0	2.2		104.9		100.4
"	XSP61151-0	2.1	1.8	97.9	102.8	98.9	100.2
FC502/2xSP581194sl	XSP5822-0	1.5	2.0	107.5		101.2	
"	XSP59B18-0	1.9	2.5	95.9		100.0	
"	XSP621160-00	1.8	2.0	107.5		99.4	
FC502/2xFC504	XSP5822-0	1.7	1.0	95.9		98.8	
"	XSP59B18-0	1.9	1.7	100.0		100.0	
"	XSP621160-00	1.7	1.5	102.1		100.2	
SP581194slxFC504	XSP5822-0	2.0	2.0	100.0	102.1	99.7	100.2
"	XSP59B18-0	2.3	2.0	101.4	98.6	99.8	98.4
"	XSP621160-00	2.1	2.0	99.3		99.7	
SP602009sloms	XSP5822-0	2.3	2.3				
"	XSP59B18-0	2.5	2.2				
FC504	XSP5822-0	1.8	1.5	93.2		99.0	
"	SP59B18-0	2.1	2.0	95.2		98.7	
FC502	X02 clone	1.9	2.3	104.8	106.3	101.0	102.0
"	XSP61151-0	1.8	2.2	102.7	103.5	101.0	100.7
SL133xFC501	X02 clone	2.3	2.8	98.6	95.8	100.4	98.5
"	XSP61151-0	2.2	2.3	100.7	97.2	100.6	98.7
"	XSP623259-04n	2.2	3.0				
SL(126x128)	X02 clone	3.1	3.3				
"	XSP61151-0	3.3	3.3				
SL(126x129)	X02 clone	3.1	3.3				
"	XSP61151-0	2.3	2.8	95.9	100.7	100.4	101.4
(SP6121x3561)3561	X02 clone	2.3	2.8	100.7	98.6	100.5	101.0
"	XSP61151-0	1.8	2.0	99.3	94.4	101.0	100.1
SP581194sloms	XSP59B18-0	2.3	2.2				
"	X02 clone	2.0	1.7	99.3	102.8	99.6	100.9
FC503	XSP59B18-0	2.1	1.8				
"	X02 clone	2.1	2.3	105.5	106.9	99.4	98.6
SP6121xEL31	X02 clone	2.5	2.7	93.8	95.1	99.1	98.9
"	XSP623259-04n	2.0	2.8	95.9	95.8	99.1	100.4
(SL133x2161)x1861	X02 clone	3.0	3.0				
sib population of	02 clone	2.8	2.2	95.2	93.1	99.2	98.9
" " "	SP61151-0	2.1	1.8	100.7	95.8	101.1	99.1
" " "	SP623259-04n	2.1	3.0				
SL(129x133)	XSP5822-0	3.2	3.7	103.4	100.0	100.2	99.5
General Mean (Actual)		2.2	2.3	14.6	14.4	93.0	91.8

Standard Footnotes b., and c. on page 343.

Consolidated results of 1965 40-1 test in Ohio and Canada. All data in percent of General Mean.

Varieties		Percent of General Mean					
		Recov. Sugar per A.[a]		Roots per Acre		Sugar per Ton	
		Ohio	Canada	Ohio	Canada	Ohio	Canada
FC(502/2x503)	XSP5822-0						
"	XSP59B18-0						
"	XSP621160-00						
"	X02 clone		93.3		87.9		106.1
"	XSP61151-0	97.3	104.0	101.2	101.1	96.5	103.3
FC502/2xSP581194sl	XSP5822-0	112.9		102.8		110.2	
"	XSP59B18-0	88.2		91.3		96.5	
"	XSP621160-00	81.0		76.7		106.7	
FC(502/2x504)	XSP5822-0	79.5		84.2		94.1	
"	XSP59B18-0	88.5		88.5		100.0	
"	XSP621160-00	81.7		79.4		103.1	
SP581194slxFC504	XSP5822-0	88.3	106.9	88.1	103.6	99.6	102.9
"	XSP59B18-0	91.1	95.0	89.7	100.7	101.2	95.5
"	XSP621160-00	92.7		93.7		98.8	
SP602009slcms	XSP5822-0						
"	XSP59B18-0						
FC504	XSP5822-0	84.9		92.5		91.7	
"	XSP59B18-0	93.9		101.2		92.9	
FC502	X02 clone	94.7	104.0	87.7	94.0	107.5	110.7
"	XSP61151-0	114.8	94.2	109.5	88.3	105.1	105.3
SL133xFC501	X02 clone	109.0	89.0	109.9	96.4	99.6	92.2
"	XSP61151-0	108.7	95.7	105.9	101.8	102.8	94.3
"	XSP623259-04n						
SL(126x128)	X02 clone						
"	XSP61151-0						
SL(126x129)	X02 clone						
"	XSP61151-0	107.1	97.5	110.3	94.0	96.9	104.1
(SP6121x3561)3561	X02 clone	123.3	108.3	120.9	107.1	102.0	101.2
"	XSP61151-0	113.4	101.6	111.9	106.8	101.2	95.1
SP581194slcms	XSP59B18-0						
"	X02 clone	95.4	98.9	96.8	94.7	99.2	104.9
FC503	XSP59B18-0						
"	X02 clone	98.4	112.2	94.5	107.8	104.3	103.7
SP6121xEL31	X02 clone	106.2	98.5	115.0	105.7	92.5	93.4
"	XSP623259-04n	103.2	104.4	110.3	108.2	94.5	97.1
(SL133x2161)x1861	X02 clone						
sib population of	X02 clone	78.7	94.9	83.8	104.3	94.1	91.4
" " "	SP61151-0	96.3	85.2	93.7	91.1	102.8	93.9
" " "	SP623259-04n						
SL(129x133)	XSP5822-0	116.2	108.1	111.5	109.6	104.7	98.8
General Mean (Actual)		6433	6851	25.3	28.1	254	244

Standard Footnote [a] on page - 343.

Consolidated Results of 1965 40-2 Test in Ohio and Ontario
(Part One)

Varieties		Entry No.	Beets/100' Ohio	Beets/100' Ontario	Leaf Spot c. Ohio 10/11	Leaf Spot c. Ontario 9/15
CT5	XSP5460-0	101		80	3.3	4.0
"	XSP5822-0	105		123	3.3	4.0
(SL129x2161)ms	XUS401 4n	103		84	3.0	3.0
"	XSP5822-0	104	76	86	2.8	3.0
"	XSP6322-0	102		108	3.5	4.0
569H3ms	XSP6322-0	115		130	2.8	3.0
648H2ms	XSP5460-0	118	59	122	2.8	3.0
"	XSP5822-0	119		67	2.8	3.0
"	XSP6322-0	114	63	99	2.5	2.5
648H3ms	XSP5460-0	126	69	133	3.0	3.0
"	XSP5822-0	112		91	2.3	2.0
"	XSP6322-0	111	77	63	2.3	2.0
(SL133xFC501)ms	XSP5822-0	132		19	2.0	2.0
((SP6121x3561)x3561)ms	XUI52	113	80	139	4.0	4.0
"	XUS401 4n	109		50	3.0	3.0
"	XSP5460-0	124	67	73	2.3	3.0
"	XUS201B	110		93	2.8	3.0
"	XSP5822-0	106		86	2.0	2.0
"	XSP6122-0	107		22	2.3	2.5
"	XSP61151-0	108	73	75	1.5	2.0
(SL129xSP6121)ms	XS132	120	67	95	2.8	3.0
(SP6121x4661)ms	XSP6256-0	131		106	2.0	2.0
"	XSP5822-0	130		105	2.0	2.5
(SP6121xEL31)ms	XSP61151-0	117	66	85	2.3	2.0
"	XSP6322-0	116	74	71	2.5	2.5
(SP6121xEL34)ms	XSP6256-0	123		53	2.3	2.5
"	XSP61151-0	122	63	59	2.0	2.0
"	XSP6322-0	121		88	2.3	2.5
(SP6121xFC501)xSP6121)	X0410	129		10	2.8	3.0
"	XSP5822-0	128		67	2.0	2.0
SP6121ms	XSP5822-0	125		89	2.5	2.5
Open Pollinated	SP64180-00	133		113	1.5	2.5
	SP64181-00	134		105	1.8	2.5
	SP64182-00	135	79	80	2.3	2.5
	SP64194-0	136	70	50	1.8	2.0
	SP64548-01	137		55	2.5	3.0
	SP64548-02	138		63	2.5	3.0
	SP643299-01	139		81	2.8	3.0
	SP643635-01-01	140		95	2.8	4.0
	SP5822-0	127	70	62	2.3	2.0
	General Mean		70	82	2.5	2.8

Standard footnote c. on page 343.

Consolidated Results of 1965 40-2 Test in Ohio and Ontario
(Part Two)

Rec. Sugar # per Acre		Roots Tons per Acre		Quality # Sugar/Ton		Entry No.	Sucrose Percent		C. J. Purity Percent	
Ohio	Ont.	Ohio	Ont.	Ohio	Ont.		Ohio	Ont.	Ohio	Ont.
	5822		27.1		215	101		12.6		92.3
	4249		19.9		216	105		12.7		91.9
	5361		25.3		213	103		12.3		92.6
7168	5368	26.7	24.3	269	220	104	15.3	13.2	93.4	91.4
	4759		20.6		231	102		12.9		94.3
	5857		25.9		227	115		13.2		92.5
6394	6263	25.3	28.4	253	215	118	14.7	13.6	92.3	89.0
	5575		22.9		245	119		13.8		93.8
6063	7055	24.9	31.5	243	224	114	14.3	13.1	91.8	92.3
6255	5186	25.0	23.3	250	223	126	14.6	13.1	92.2	91.9
	4466		19.5		229	112		13.5		91.9
7069	4079	27.1	19.1	261	214	111	14.8	12.8	93.6	91.4
	2315		10.5		226	132		13.4		91.7
6916	5370	30.2	23.4	229	220	113	13.7	13.7	91.0	91.2
	4024		17.8		225	109		12.7		93.8
7489	5389	29.1	24.4	257	221	124	14.9	13.1	92.6	91.5
	5686		26.0		220	110		13.7		89.7
	6682		28.3		236	106		13.3		93.7
	2423		11.3		210	107		12.6		91.2
7518	5527	30.0	24.4	251	226	108	14.1	13.1	93.9	92.7
7954	6633	29.4	29.0	270	231	120	15.6	13.0	92.6	93.7
	6159		27.3		225	131		13.2		92.0
	6825		29.4		232	130		13.0		94.2
6197	5551	25.5	24.7	242	225	117	14.3	13.4	91.8	91.3
7242	5311	27.8	24.3	260	218	116	15.1	12.9	92.6	91.8
	4101		18.0		228	123		13.4		91.8
6630	3407	26.2	14.2	252	238	122	14.5	13.7	93.0	92.8
	4824		22.1		218	121		12.8		92.0
	760		3.2		238	129		13.5		93.6
	5438		23.7		226	128		13.3		91.9
	4862		22.3		218	125		12.5		93.3
	4528		19.3		235	133		13.4		93.4
	5513		24.0		230	134		13.3		92.7
7527	4461	31.3	19.3	240	231	135	14.1	13.1	91.9	93.7
6585	3306	28.1	16.0	235	206	136	13.7	11.9	92.2	92.9
	4245		19.1		223	137		12.9		92.8
	4437		21.4		208	138		12.4		91.5
	4808		22.9		210	139		12.8		90.5
	3655		18.8		194	140		12.5		88.3
6687	3826	25.9	17.4	259	220	127	14.6	13.1	93.6	91.3
6913	5413	27.5	24.3	252	223	GM	14.5	13.1	92.6	92.0

AGRONOMIC EVALUATION TEST OF LSR-BRR, EXPERIMENTAL HYBRIDS
FT. COLLINS, COLO., 1965

Experiment No. 4A

Conducted by: J. A. Elder and J. O. Gaskill; East Lansing seed furnished by G. J. Hogaboam.

Location: Hospital Farm, Ft. Collins, Colo., field no. 2.

Cooperation: Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation.

Dates of Planting and Harvest: April 29-30; October 4-11.

Experimental Design: Randomized Block design with 6 replications; plots 1 row x 20'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in 17' of row were hand topped, washed and weighed.

Determination of Sucrose Percentage: All roots harvested for root-yield determination in each plot were analyzed for sucrose percentage. Duplicate sucrose determinations were made for the composited pulp from each sample.

Stand and Bolter Counts: For stand, all hills were counted on September 30 in the area to be harvested in each plot. Bolter percentages were determined by counts (entire plots) in mid-season, and seed stalks were cut off at that time.

Recent Cropping History: 1961, sugarbeet; 1962-64, barley.

Chemicals Applied for 1965 Crop: Treble super-phosphate (approximately 130 lbs. P_2O_5 per acre) and ammonium nitrate (approximately 80 lbs. N per acre) were applied before plowing in August, 1964. Shell DD (about 41 gal. per acre) was applied after plowing in August, 1964, for control of the sugarbeet nematode.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Western yellows and sugarbeet nematode, mild effects; other diseases and pests, negligible.

Soil and Seasonal Conditions: The first half of the 1965 crop season was cooler and wetter than usual. Precipitation was quite heavy during June. Adequate soil moisture was provided artificially as needed, principally by furrow irrigation. Inoculation (July 12) and subsequent frequent sprinkling were used to promote the development of leaf spot (*Cercospora beticola*).

Reliability of Test: Good.

AGRONOMIC EVALUATION TEST OF LSR-BRR, EXPERIMENTAL HYBRIDS, FT. COLLINS, COLO., 1965

Experiment No. 4A

(Results presented as 6-plot averages)

Description ♀ (CMS)	♂	Seed no.	Entry no.	Acre yield Gross Sucrose	Roots	Sucrose	Leaf spot[a/] 8/24	Leaf spot[a/] 9/1	Vigor[b/] 8/9	Stand (plants per 100')	Bolters
				Lbs.	Tons	%				No.	%
I. Experimental Hybrids and Pollinators from E. Lansing, Mich.											
Sib of 62B1-01 (02 clone)		64B1-01	201	3104	10.85	14.29	2.4	3.3	6.5	115	0.00
621209H01	62B1-01	" x02	202	3979	12.49	15.91	2.1	2.4	6.7	107	0.00
631201H01	"	" x03	203	4498	14.54	15.46	1.9	2.6	7.0	113	0.00
631201H02	"	" x04	204	4325	13.73	15.75	1.9	2.3	6.8	113	0.75
631229H01	"	" x05	205	3871	12.22	15.83	1.9	2.3	7.0	111	0.83
SL 133ms x FC 501	"	" x06	206	4403	14.49	15.20	2.1	2.2	6.8	112	0.00
126 x 128	"	" x08	207	4113	13.62	15.09	3.7	4.3	6.8	112	0.00
126 x 129	"	" x09	208	3934	13.20	14.90	3.8	4.7	7.2	110	0.00
(SP 6121 x 3561)ms x 3561	"	" x010	209	4206	14.19	14.82	2.1	3.0	7.2	114	0.80
SP 6121 x EL 61G1	"	" x011	210	3793	13.04	14.54	2.2	2.4	5.8	114	0.00
Sib of 62B2-01 (5822-0)		64B2-01	211	3196	10.35	15.42	1.7	1.8	6.2	110	0.00
621209H01	62B2-01	" x02	212	4063	12.77	15.92	2.3	2.7	7.0	112	4.13
631201H01	"	" x03	213	4437	13.92	15.94	1.5	2.2	7.8	112	0.00
631229H01	"	" x05	214	4163	13.00	16.00	1.0	1.4	7.2	107	0.00
SL 133ms x FC 501	"	" x06	215	4069	13.13	15.44	1.3	1.4	7.3	116	0.00
(SL 133 x 2161)ms x 1861	"	" x07	216	4146	13.41	15.45	2.8	3.8	6.2	119	0.00
126 x 128	"	" x08	217	3964	12.78	15.51	3.1	3.8	6.8	117	0.00
126 x 129	"	" x09	218	3882	12.51	15.51	3.0	3.7	6.8	115	0.00
(SP 6121 x 3561)ms x 3561	"	" x010	219	4148	13.70	15.12	1.3	1.3	7.3	115	0.00
(SL 133 x 2161)ms x 1861	623259-01	64B3x07	220	3692	12.31	14.98	4.7	5.3	6.3	115	0.00
126 x 128	"	" x08	221	3344	11.07	15.06	4.1	4.5	6.7	110	0.00
126 x 129	"	" x09	222	3531	11.40	15.48	3.3	3.9	6.5	111	0.00
(SP 6121 x 3561)ms x 3561	"	" x010	223	3816	12.51	15.25	2.5	2.8	7.2	112	0.75
SP 6121 x EL 61G1	"	" x011	224	3585	12.10	14.81	3.1	3.5	6.5	114	0.00
II. Checks and Miscellaneous Material											
FC (502/2 x 503)	SP 59B18-0	SP 641202H01	225	4701	14.79	15.89	1.8	2.0	7.0	118	0.72
FC (502/2 x 504)	" "	" 641202H03	226	4656	14.87	15.68	1.5	1.5	6.8	112	0.00
B.C. Sug. Ref. Co. var. CS 42 [c/]		Acc. 2640	227	2963	10.84	13.64	6.6	6.8	5.5	108	0.00
Com. hyb. SL (129 x 133)MS x SP 5822-0		Acc. 2634	228	3895	13.01	14.96	3.0	3.2	6.7	114	0.80
General mean				3946	12.89	15.28	2.6	3.0	6.8	113	----
S. E. of entry mean				151.73	0.4794	0.1592	0.23	0.27	0.19	2.64	----
S. E. of entry mean as % of gen. mean				3.85	3.72	1.04	8.74	8.97	2.79	2.35	----
L.S.D.(.05)				424	1.34	0.44	0.6	0.8	0.5	7	----
F for entries				8.44**	6.48**	11.92**	28.16**	23.03**	6.54**	1.24	----

a/ Leaf spot grades: 0 = no leaf spot; 10 = complete defoliation.

b/ Foliage vigor: larger no. = greater vigor.

c/ Ramularia resistant variety.

** F equal to or greater than the 1% point.

AGRONOMIC EVALUATION TEST, 1965

Miscellaneous Variety Test

Conducted by: Phil Brimhall, R. Zielke,* H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: May 11, 1965

Date of Harvest: October 14, 1965

Experimental Design: Randomized Complete Block

Size of Plots: 1 row x 22 feet x 8 replicates
(30-inch rows)

Harvest Area per Plot for Root Yield: 1 row x 18 feet

Samples for Sucrose Determination: 1 sample per plot

Stand Counts and Bolter Counts: Beets counted in laboratory for stand. No bolters developed.

Recent Field History: Sugar beets (1964) spring plowed

Fertilization of Beet Crop: 500 pounds 5-20-20
plow down, 150 pounds 6-24-12
starter fertilizer in row, 55 pounds anhydrous
ammonia sidedressed

Leaf Spot Exposure: Mild, September development

Black Root Exposure: Severe, some loss of stand

Curly Top Exposure: None noted

Other Diseases: None noted

Soil and Seasonal Conditions: Beet emergence good, but seedlings badly infested with black root organisms. Moisture conditions good throughout growing season. Soil was a clay loam.

* Zielke now employed by USDA, East Lansing, Michigan.

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, R. Zielke, H. L. Bush, R. K. Oldemeyer, D. L. Sunderland

Miscellaneous Variety Test

Location: Glen Haas Farm, Fremont, Ohio Year: 1965

(Results given as 8 plot averages)

	Acre Yield Sugar Recoverable[a] (lbs.)	Acre Yield Sugar Gross (lbs.)	Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Leaf Spot[d] 10/5/65	Black Root[e] 6/25/65	Beets per 100 ft.[f] (No.)
SP64548-01	4319	4986	16.84	14.75	93.55	1.2	3.1	102
64Bl x 05	3946	4331	13.79	15.65	95.98	0.8	4.2	82
64Bl x 04	3893	4398	14.28	15.44	94.54	0.8	4.0	83
SP64180-0	3768	4325	14.81	14.59	93.85	0.8	3.1	106
SP64182-0	3700	4251	14.76	14.36	93.81	1.3	2.6	91
SP5822-0	3647	4147	14.10	14.73	94.29	1.1	2.0	96
SP64194-0	3480	4042	13.94	14.46	93.30	1.1	2.6	93
SP64181-0	3265	3785	12.87	14.68	93.38	1.0	2.6	94
General Mean[g]	3726	4251	14.40	14.76	94.10	-	-	
S.E. Variety Mean (Sm)	-	233.24	.7458	.2669	.5786	-	-	-
Sm/Gen. Mean (%)	-	5.49	5.18	1.81	0.61	-	-	-
LSD 5% pt.	577[b]	658	2.10	0.75	1.63	-	-	-

Variance Table[c]

Source of Variance	DF	Mean Squares Roots[h] (lbs.)	Mean Squares Sucrose (%)	Mean Squares Purity (%)
Replicates	7	94.7185	2.6771	1.5514
Varieties	10	48.9960	1.4960	5.1300
Error	70	19.0170	.5724	2.6777
Total	87	28.5537	.8479	2.8920
Calculated F Value		2.58*	2.61**	1.92*

(a, (b, (c See page 357.
(d 0 = no evidence of disease, 10 = complete necrosis due to leaf spot
(e 0 = excellent resistance, 10 = no resistance
(f Harvest stand
(g General mean for 11 varieties in test
(h Pounds per plot

AGRONOMIC EVALUATION TEST, 1965

Miscellaneous Variety Test

Conducted by: Phil Brimhall, R. Zielke*, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: George Riehm Farm, Old Fort, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: April 22, 1965

Date of Harvest: October 12, 1965

Experimental Design: Randomized Complete Block

Size of Plots: 1 row x 22 feet x 8 replicates
(28-inch rows)

Harvest Area per Plot for Root Yield: 1 row x 18 feet

Samples for Sucrose Determination: 1 sample per plot

Stand Counts and Bolter Counts: Beets counted in laboratory for harvest stand. No bolters developed.

Recent Field History: Sugar beets (1964) spring plowed

Fertilization of Beet Crop: 500 pounds ammonium sulfate
150 pounds 6-24-12 starter fertilizer in row

Leaf Spot Exposure: Very severe, late August development

Black Root Exposure: Mild, few seedlings affected

Curly Top Exposure: None noted

Other Diseases: Rhizoctonia crown rot, causing some loss of stand

Soil and Seasonal Conditions: Moisture good for germination and seedling development. Dry period from July 15-August 15. Adequate moisture from August 15 to harvest. Soil was a sandy loam.

* Zielke now employed by USDA, East Lansing, Michigan.

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, R. Zielke, H. L. Bush, R. K. Oldemeyer, D. L. Sunderland

Miscellaneous Variety Test

Location: George Riehm Farm, Old Fort, Ohio

Year: 1965

(Results given as 8 plot averages)

	Acre Yield Sugar Recover-able[a] (lbs.)	Acre Yield Sugar Gross (lbs.)	Acre Yield Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Leaf Spot[d] 8/29/65	Beets[f] per 100 ft. (No.)
64B1 x 010	5707	6454	24.45	13.18	94.65	2.5	125
64B2 x 010	5501	6275	23.42	13.41	94.20	1.5	133
64B1 x 011	5374	6231	23.43	13.25	93.44	3.0	128
64B1 x 05	4969	5613	20.05	14.03	94.65	2.4	125
SP5822-0	4774	5469	20.41	13.44	94.00	2.5	133
SP64548-01	4576	5137	19.46	13.23	95.01	2.8	125
64B1 x 04	4487	5141	19.18	13.40	93.99	2.3	127
SP64180-0	4137	4824	18.99	12.70	93.23	2.5	131
SP64182-0	3608	4189	16.62	12.58	93.43	2.8	114
SP64194-0	3486	4114	16.72	12.29	92.69	2.6	124
SP64181-0	3319	3916	15.66	12.49	92.70	3.0	124
General Mean[g]	4462	5144	19.71	13.05	93.73	-	-
S.E. Variety Mean (Sm)	-	316.97	2.2295	.2466	.4378	-	-
Sm/Gen. Mean (%)	-	6.16	5.87	1.89	0.47	-	-
LSD 5% pt.	772[b]	890	3.25	0.69	1.23	-	-

Variance Table[c]

Source of Variance	DF	Mean Squares Roots[h] (lbs.)	Mean Squares Sucrose (%)	Mean Squares Purity (%)
Replicates	7	21.6543	5.9257	2.1514
Varieties	13	221.5069	2.1108	6.1238
Error	91	39.7626	.4864	1.5337
Total	111	59.9060	1.0196	2.1103

(a, (b, (c See page 357.
(d 0 = no evidence of disease, 10 = complete necrosis due to leaf spot.
(f Harvest stand
(g General mean for 14 varieties in test
(h Pounds per plot

(a Recoverable Sugar [1/]

A technique, whereby thin juice purity could be determined from small samples, was first used in 1953, following methods developed in the G. W. Research Laboratory at Denver. Using the resultant purity figure, a calculated "Recoverable Sugar" is obtained. An example of the calculation is as follows:

Sugar in beets = 12.00%
Standard total losses = 0.30%
Sugar on beets at sugar end - 12.00 - 0.30 = 11.70%

Assume standard molasses purity = 62.5%
100.0 - 62.5 = 37.5% Impurities on solids in molasses
$\frac{62.5}{37.5}$ = 1.6667% Sugar on impurities in molasses

Sugar sacked
85% purity thin juice = 15% impurities
$\frac{15}{85}$ = 17.6471% impurities on sugar

Sugar end = 11.70 x 17.6471% = 2.06471% on beets
Molasses produced = 2.06471 x 1.66667 = 3.4413% on beets
Sugar sacked = 12.00 - (0.30 + 3.4413) = 8.2587%

$$\text{Recoverable sugar} = \frac{8.2587}{12.00} = 68.82\%$$

(b Approximation - Calculated as percentage of "difference required for significance for "gross" sugar on basis of relationship between general means for "Gross" and "Recoverable" sugar.

(c Gross sugar calculated from the formula:

$$\text{S lbs. sugar} = \text{Mean lbs. sugar} \sqrt{\left(\frac{\text{S lbs. beets}}{\text{Mean lbs. beets}}\right)^2 + \left(\frac{\text{S \% sugar}}{\text{Mean \% sugar}}\right)^2}$$

[1/] For use of this method, see pages 354 and 356.

PART XII

FUNGOUS DISEASES

Cercospora Leaf Spot Investigations[1]

Lucas Calpouzos

G. F. Stallknecht

- - -

Selecting for Storage Rot Resistance[2]

D. L. Mumford

C. G. Filban

G. J. Hogaboam

Cooperation:

1/ University of Minnesota

2/ Michigan State University

Cercospora Leaf Spot Investigations [1/]

L. Calpouzos and G. F. Stallknecht

In 1965 there were 185,000 - 190,000 acres of sugar beets in northern Iowa, Minnesota and eastern North Dakota. It is estimated that significant amounts of Cercospora leaf spot occurred only on about 3 percent of this acreage and that seedling rot or damping off occurred also on about 3 percent. Other diseases were not present in more than trace amounts. Our research activities for the year included both field and laboratory studies on Cercospora leaf spot.

Leaf Spot Disease Survey in Minnesota and North Dakota

Reliable, quantitative data on the incidence and distribution of leaf spot in Minnesota are not available. The grower needs this information to determine whether a spray program is economically justified in his area. The researcher also needs this information to learn more about the epidemiology of the disease.

This year a disease survey of Minnesota and eastern North Dakota was established with the intent to continue it on a regular annual basis. Our appreciation goes to Drs. H. G. Johnson and H. L. Bissonnette, Extension Plant Pathologists for Minnesota and North Dakota, respectively, who played a major role in conducting the 1965 disease survey.

Ninety-seven fields were randomly selected throughout the surveyed area. Each field was noted for disease three times during the growing season: in mid-July, mid-August and mid-September. This procedure gave us a dynamic picture of disease increase where it occurred. Disease rating was based on the Kleinwanzlebener system of 0 to 5, where 0 means no disease and increasing numbers reflect increasing disease incidence up to a maximum of 5 where on every plant most of the leaves are killed by leaf spot. In practice we were able to observe only a small portion of each field; however, we believe that for the broad geographical area the general picture of disease incidence was accurate.

Some of the fields were sprayed with fungicide. Out of the 97 fields observed, 3 had a visible fungicide deposit in

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1/ In cooperation with the Department of Plant Pathology and Physiology and the Agricultural Experiment Station, University of Minnesota, St. Paul.

mid-July, 19 in mid-August and one in mid-September. The small number of fields treated with fungicide was probably insufficient to mask the presence of disease in the surveyed area.

On the mid-July trip, no more than trace to slight disease incidence (0.1 to 1.0 rating) was found, and this only on 16 fields located in Cass, Clay and Polk counties of the Red River Valley; and in Renville, Martin and Waseca counties of central and southern Minnesota.

On the mid-August trip, 57 fields showed disease. Of these, only 7 had a disease rating above 1 and none had a disease rating above 2. The fields showing disease were dispersed throughout the Red River Valley (Cass, Walsh, Traill, Clay, Norman, Polk and Marshal Counties) and the sugar beet areas of central and southern Minnesota (Swift, Chippewa, Renville, and Martin and Waseca counties, respectively).

On the mid-September trip, 51 fields showed disease. Of these, seven fields were rated between 1 and 2, one field was rated 3, and the rest had a rating of 1 or less. The geographical distribution of diseased fields was similar to that reported for the mid-August trip, except for Traill and Marshal counties in which we found no disease, and for Faribault county (southern Minnesota) where we found disease for the first time.

No one knows at what minimal disease rating sugar yield begins to suffer. Nevertheless, if we choose as a tentative criterion that a disease rating of 2 by mid-September is necessary for a noticeable loss in yield, then we conclude that in 1965 Cercospora leaf spot was relatively unimportant as an economic factor in Minnesota and North Dakota, since in September only three fields had a disease rating of 2 or greater. Compare the 1965 results with those from cursory surveys taken in September, 1963, and September, 1964, in the area between E. Grand Forks, Crookston and Moorhead (Polk, Norman, and Clay counties). In 1963 and 1964, roughly one-half of the randomly sampled fields had a disease rating of 2 or greater, indicating that damaging amounts of disease were much more common than the 3 percent of the fields observed in 1965.

The reason for the low amount of leaf spot disease in 1965 was probably due to the weather conditions. Records from the Fargo-Moorhead area (Cass and Clay counties) show that rainfall was above average for May, July, and September, and only slightly below average for June and August. Moisture, therefore, was probably not a limiting factor for disease development.

On the other hand, temperatures were low. May and June were slightly below the 30-year average, but July and August rank 6th and 5th, respectively, as the coolest for the last 30 years. September, 1965, broke the 30-year record for the lowest average temperature for that month. We speculate that the unusually cool temperatures of July, August, and September, 1965, were responsible for the unusually small amount of leaf spot disease. The low temperatures probably greatly increased the time required for the fungus to complete its life cycle, which in turn would result in fewer infections.

The Timing of Fungicide Sprays Affects Leaf Spot Control and Sugar Yield

The classic picture of a plant disease epidemic can be plotted as a sigmoid curve with the X axis representing time and the Y axis representing disease incidence. At the beginning of the epidemic there is very little disease increase with time; then in the second stage of the epidemic, disease increases very rapidly with time; finally, in the last stage, the large amount of disease remains fairly constant with time. A successful fungicide program should prevent the second and final stages of the epidemic since the economic losses occur during and after the rapid build-up of disease. Cercospora leaf spot seems to follow the type of disease epidemic just described.

On theoretical grounds, an effective fungicide program should probably begin at the transition between stages 1 and 2. In the field this point of the epidemic would occur when about half of the plants are starting to show a few scattered spots on several leaves. The disease rating for such a field would be around 0.5 (on the 0-5 scale). We conducted an experiment to test the effectiveness of a standard spray program which began at different dates from the time that the first few spots appeared in the field (rating 0.5).

The experiment was carried out at Mason City, Iowa, with the cooperation of the Research Department of the American Crystal Sugar Company to whom we express our gratitude. The standard fungicide schedule consisted of four sprays, each separated by 2-week intervals. The same fungicide, Dithane M-45, at 2 lbs in 40 gallons of water per acre was used throughout. We tried to control the experimental factors except for the dates of the spray applications. The date of the first spray for each of the six treatments was as follows:

(1) July 1, 1965, appearance of first spots (0.5 disease rating).
(2) July 7. (3) July 14. (4) July 21.
(5) July 28. (6) No spray - check.

Each treatment consisted of six replicate plots, each containing four 25-foot rows of sugar beets. The plots were uniformly sprayed with a tractor mounted hydraulic sprayer. Only the center two rows of sugar beets from each plot were used for yield data.

The disease epidemic progressed slowly. The disease incidence rating in the check plots was 0.5 in early July, about 1.0 in early August, about 4 in early September, and 5 in early October. The plots were harvested during October 18-19, 1965.

Table 1 presents the average yield data from the experiment. In terms of total sucrose per acre, all treatments gave significantly higher yields (5% level) than the checks. Treatments 2 and 1 were significantly better than treatment 4, while treatments 3 and 5 were intermediate. There is a trend toward better disease control with the spray schedules begun at the time when the spots first appeared or one week later.

The higher total sugar yield with the early spray schedules resulted primarily from higher root tonnage. The percent sucrose data showed no clear trend. The highest percent sucrose came with the last spray schedule (no. 5), perhaps because the fungicide was protecting the plants when they were beginning to "sugar-up" in September. On the other hand, the lowest percent sucrose of the treatments occurred with schedule no. 4 which terminated only one week before schedule no. 5. This is surprising and cannot be readily explained. In percent purity, no significant differences existed between the treatments or the check, and no trend seemed evident.

These data are among the first available on the importance of when fungicide sprays are applied with respect to the first appearance of disease in the field. The results indicate that an early start will increase the tons of roots; however, further experiments should be carried out again, especially in a season when disease builds up rapidly (unlike 1965), before drawing any final conclusions.

Table 1. Yields from sugar beet plots treated with a 4-spray fungicide schedule started at different times from the first appearance of leaf spot disease.[a]

Treatment number	Spray dates	Sucrose per acre lb	Beet roots per acre tons	Sucrose %	Purity %
1	July 1, 15, 29; Aug. 12	3381	14.40	11.74	90.6
2	July 7, 21; Aug. 4, 18	3429	14.31	11.98	88.5
3	July 14, 28; Aug. 11, 25	3314	13.67	12.12	89.9
4	July 21; Aug. 4, 18; Sept. 1	2913	12.58	11.58	88.6
5	July 28; Aug. 11, 25; Sept 8	3256	12.94	12.58	89.8
check	No spray	2419	11.63	10.40	88.4
	LSD (0.05)	437	1.48	0.99	NS

[a] Each value is the average six replicate plots. This experiment was carried out in cooperation with the Research Department of the American Crystal Sugar Company.

Sporulation of Cercospora beticola is Stimulated by Light only at a Specific Time after Inoculation

In last year's research report (see also Phytopathology 55: 1370-1371. 1965.) we showed that white light significantly stimulates sporulation of *C. beticola* cultures held at 15°C during a 7-day incubation period. We wanted now to determine whether a shorter exposure to light could equal the effect produced by the 7-day exposure.

In this experiment a single-spore isolate of *C. beticola* originating from Iowa was grown on sugar beet leaf extract agar in petri dishes. The agar was inoculated with 0.3 ml of a spore suspension which resulted in uniform growth of the same age developing over the entire surface of the agar. From the time of inoculation, the plates were kept in the dark at 15°C for 7 days except for a single 24-hr. exposure to 80 ft -c of white light (cool white fluorescent lamp) at 15°C. The experimental checks consisted of plates kept constantly either in the dark or in the light at 15°C.

Each treatment consisted of three replicate plates. At the end of the seventh day a disk of uniform size consisting of agar and fungus was removed from the center of each plate and placed in a test tube containing 10 ml of water. The test tube was thoroughly shaken for one minute, and the resulting spore suspension was sampled six times to determine the spore concentration by means of a hemocytometer.

The experiment was repeated three times with parallel results. Table 2 presents the spore counts averaged from the three experiments. Exposure to white light during the 4th day (72nd to 96th hr. after inoculation) resulted in a marked increase in sporulation almost equalling the sporulation induced by a 7-day exposure to white light. Exposure to white light before or after the 4th day had little or no effect on sporulation when compared to the fungus cultures kept in constant darkness.

These results indicate that at 15°C the sporulating fungus is responsive to light only during the 4th day of its growth. The biochemical and physiological basis of this response should be investigated.

Table 2. Effect of a single 24-hr. exposure to white light on the sporulation of *Cercospora beticola* incubating for 7 days at 15°C.

Time of exposure to light (days after inoculation)	Average spore count[a] (spores/ml water)
1	53,000
2	50,000
3	70,000
4	130,000
5	50,000
6	48,000
7	38,000
check (constant light)	143,000
check (constant dark)	45,000

[a] Each value is the average for three replicate experiments.

Riboflavin and Sporulation of *Cercospora beticola*

There is a need to determine the physiological mechanism controlling sporulation in *C. beticola* since the fungus sporulates erratically. The medium is widely recognized as an important factor influencing sporulation; however, the significant components of the medium which favor sporulation remain unknown. A recent report (J. Amer. Soc. Sugar Beet Technol. 11: 400. 1961.) mentioned that sporulation of *C. beticola* was increased many times on Czapeks' agar (a synthetic medium) by the addition of a small amount of riboflavin. We wished to check this report with one of our fungus isolates originating from Iowa.

Riboflavin was added to Czapek's agar to make concentrations of 1, 10, and 100 ppm. The check consisted of Czapek's agar with no added riboflavin. The batches of agar were then autoclaved and poured into 5-cm petri dishes. Each dish was flooded with 0.3 ml of washed spores of *C. beticola*. There were three agar plates for each riboflavin concentration; two plates were incubated under a diurnal cycle of light and darkness; the third plate was incubated in constant darkness. All plates were kept in temperature cabinets set at 15°C for 7 days and were then examined for spores, using the standard method described in the preceding report.

Of the cultures kept in constant darkness, none had spores. Most of the cultures exposed to diurnal light had spores as the following data show:

Riboflavin concentration ppm	Average no. of spores/ml of suspension	
	Replicate plate no. 1	Replicate plate no. 2
0	15,000	1,600
1	8,300	0
10	15,000	6.600
100	6,600	6,600

The variation in spore counts between replicate plates generally was large and no marked trend was apparent. With our fungus isolate growing on Czapek's agar, we were unable to find any obvious stimulation of sporulation in the presence of added riboflavin.

A Comparison of the Protective Properties of Three Fungicides against Spores of *Cercospora beticola*.

Triphenyl tin hydroxide provides excellent disease control, often resulting in 50 percent fewer leaf spots than those found on sugar beets sprayed with either copper or maneb fungicides. Sugar yields per acre are often 50-75 percent higher for the tin fungicide treatments than for the copper or maneb treatments.

Although the majority of evidence from the field indicates that the tin compound is an outstanding fungicide against leaf spot of sugar beets, there is almost nothing known of its mode of action against *Cercospora beticola*. Most fungicides are protectants, since they act on the surface of the host to prevent invasion by pathogens. Therefore, in the present study the protectant properties of triphenyl tin hydroxide were compared with those of Tribasic copper and Dithane M-45 (a maneb derivative), which are typical protectant fungicides. The following properties of the three compounds were studied; toxicity toward spore germination, tenacity on leaf surfaces exposed to simulated rain, ability to distribute over the entire leaf surface, and the diameter of the fungicide particles.

Materials and Methods. The conidia used in the experiments were obtained from an isolate cultured on sugar beet leaf extract agar. The plates were inoculated by taking a section of a sporulating colony and touching it to the entire surface of the agar plate. The cultures were grown in an incubator set at 22 C with alternate light and dark periods of 12 hr. each. Spores were obtained from 6-day-old cultures by flooding the plates with water and then brushing the colonies lightly with a 0.5-inch artist's brush. The spores were washed in a Millipore filter column (15 ml capacity) by 5 rinses of distilled water. Spore counts were made and the volume of the spore suspension was adjusted to give a spore concentration of approximately 50,000 spores per ml in all experiments.

Three-month-old plants of sugar beet variety 3-S from the American Crystal Sugar Company were used. All experiments involving plants were conducted under similar controlled environment conditions.

Triphenyl tin hydroxide comes as a wettable powder with 20 percent active ingredients. The maneb fungicide, Dithane M-45, is a co-ordination product of zinc and managanese ethylenebisdithio-carbamate, and is a wettable powder with 80 percent active ingredients. The copper fungicide, Tribasic Copper Sulfate, contained 53 percent metallic copper. The copper and maneb fungicides are being used commercially for the control of Cercospora leaf spot on sugar beets and were included as comparative standards for the tin fungicide. The final fungicide concentrations used

in the spore germination tests were based on the percent of active material present. The fungicide concentrations in the tenacity and distribution studies were equivilent to field rates; 80 gallons of water with either 2 pounds of maneb, or 5 pounds of copper, or 0.5 pound of tin. In the experiments concerned with fungicide tenacity and distribution on the leaves, a spreader-sticker, Triton B-1956, was added to each fungicide suspension at a concentration equivalent to 4 oz per 80 gallons of spray.

On the leaf surfaces a 1 percent crystal violet dye solution was used to stain the spores. The inoculated leaf area was cut from the leaf blade and placed on a glass slide. The light beam from the microscope was directed from below, through the intact leaf tissue. The spores were easily observed at a magnification of 100X. In all experiments the spores were arbitrarily considered germinated if each spore had one germ tube at least 10 microns long.

Results. Spore germination on glass slides. Three 0.02 ml droplets of spore-fungicide mixture were deposited on a slide. Three slides were used for each fungicide concentration. The slides were kept in a moist chamber at near saturate humidity for 24 hr. in a dark incubator set at 25 C. One hundred spores per droplet were observed for germination, totaling 300 spores per slide. The experiment was replicated three times.

The usual practice is to present fungicide toxicity data in terms of percent spore germination only. Differences in germ tube length are not included. We found instances where spores at different fungicide concentrations had the same percent germination but markedly different average germ tube lengths. These observations clearly indicated different degrees of toxicity even though the percent germination was the same. Therefore, we devised a germination index (whose values were derived from the percent germination multiplied by the average germ tube length in microns) to present a more accurate picture of fungicide toxicity than that derived from percent germination alone.

Table 3 presents the germination index concentrations of the three fungicides, and shows large differences in toxicity between the tin fungicide on the one hand and the copper and maneb fungicides on the other. The tin compound at a concentration of 0.01 ppm gave a germination index of zero, whereas copper and maneb required more than 10 ppm to cause similar inhibition.

Spore germination on leaves. Three replicate leaves attached to each of 3 plants were dipped into one concentration of a fungicide and allowed to dry. The plants were then placed in a humidity chamber. Droplets of spore suspension were deposited on each of the treated leaves, and then the humidity chambers were sealed immediately. The chambers were kept at approximately 25^{o}C. After 24 hr., the plants were removed from the chambers. Five inoculated areas per leaf were observed for germination. The experiment was repeated three times.

Table 3. Spore germination on glass slides in the presence of triphenyl tin hydroxide, Tribasic copper sulfate, or Dithane M-45.

Concentration of fungicide in ppm.	Germination index x 10^{-3}[ab]
TIN	
0.001	24.50
0.005	5.85
0.0075	1.80
0.010	0.00
COPPER	
0.1	23.53
0.5	6.10
1.0	5.46
5.0	1.74
10.0	0.44
M-45	
0.1	24.75
0.5	8.70
1.0	7.60
5.0	2.16
10.0	0.52

[a] The average is based on 27 spots on 9 slides: 100 spores observed per spot.

[b] Germination index value based on the average percent spore germination multiplied by the average germ tube length in microns.

In Table 4, the results show that on sugar beet leaves the tin compound gave a germination index of zero at 1 ppm, whereas the copper and maneb fungicides required 1000 ppm to cause similar inhibition. These dosages are about 100 times greater than those necessary for zero germination index in the glass slide tests.

Tenacity of the fungicides on leaves. One experiment was performed to investigate the tenacity of the fungicides under simulated rain treatments. Three plants were used per fungicide concentration. Three leaves of each plant were dipped in the fungicide suspension. The plants were exposed to 1.5 inches of simulated rain on the 2nd, 5th, 10th, 16th, and 22nd day after the leaves were dipped in the fungicide suspensions.

Twenty-four hr. after each rain treatment, one 10 mm. disk was removed from each of the 3 treated leaves on each plant. The disks were placed on 1.2 percent water agar in petri plates which served as humidity chambers. One droplet of spore suspension was placed in the center of each leaf disk. The inoculated leaf disks were incubated for 24 hr. in a dark incubator set at 25 C. After 24 hr., the leaf disks were removed from the humidity chamber, were allowed to dry, and were then stained with crystal violet dye solution, and on each disk 100 spores were observed for germination.

The tin fungicide stopped spore germination until the 22nd day, when an average of 20 percent germination was observed. The copper treated leaves showed 10 to 30 percent spore germination throughout the experiment, while the maneb treated leaves had 30 to 80 percent spore germination. Neither copper nor maneb resisted washing as well as the tin compound.

Distribution of the fungicides on the leaf surface. In one experiment, each fungicide was applied to 3 leaves of 5 plants by dipping the leaves in the fungicide suspension. Twenty-four hr. after the fungicide was applied to the leaves, three 10 mm. disks were removed at random from each of the fifteen treated leaves. Inoculation and incubation procedures were the same as in the tenacity tests.

Table 5 shows that all sampled areas from the tin treated leaves had sufficient toxicant to completely inhibit spore germination, thereby indicating excellent fungicide distribution. By contrast, the leaf samples from the copper and maneb treatments occasionally had insufficient toxicant to stop germination, thereby indicating poorer fungicide distribution than that obtained with the tin compound. The copper and maneb fungicides protected only an average of 69 and 76 percent, respectively, of all the leaf samples observed.

Table 4. Spore germination on sugar beet leaf surfaces in the presence of triphenyl tin hydroxide, Tribasic copper sulfate, or Dithane M-45.

Concentration of fungicide in ppm.	Germination index x 10^{-3} [ab]
TIN	
0.01	24.50
0.10	4.90
1.00	0.00
COPPER	
10.00	23.25
100.00	5.11
500.00	2.46
1000.00	0.32
M-45	
10.00	24.50
100.00	7.40
500.00	1.96
1000.00	0.00

[a] The average is based on 135 droplets on 27 treated leaves from three experiments.

[b] Germination index value is based on the average percent germination multiplied by the average germ tube length in microns.

Table 5. Distribution of triphenyl tin hydroxide, Tribasic copper sulfate, and Dithane M-45 on sugar beet leaves as assayed by spore germination of *Cercospora beticola*.

Replicate Plant No.	Average percent leaf area sampled having sufficient fungicide to inhibit spore germination.[a]		
	Tin	Copper	Maneb
1	100	33	78
2	100	78	100
3	100	67	56
4	100	89	67
5	100	78	67
Total average	100	69	76

[a] Germination was checked on 3 areas of each of 3 leaves per plant. Each average for a replicate plant is based on 9 leaf areas. The values were obtained by dividing the no. of disks observed per plant into the no. of disks on which germination did not occur and multiplying by 100.

Fungicide particle size measurements. Particle size of fungicides has been known to influence toxicity; the smaller the particle size,the greater the activity of the compound. Therefore, measurements were made on the particle sizes of the tin, copper, and maneb fungicides since it was thought that perhaps the high toxicity of the tin compound may be due to an unusually fine particle size.

Droplets of each fungicide suspension were deposited on three glass slides and observed under a compound microscope, at 900X magnification. The approximate particle diameter for the tin ranged from 0.3 microns to 0.5 microns; for copper, 0.4 to 0.7 microns; and for maneb, 1.0 to 1.5 microns. It was also noted that the copper and maneb fungicides had a tendency to form clumps readily, whereas the tin fungicide formed none.

Discussion. Triphenyl tin hydroxide, Tribasic copper sulfate, and Dithane M-45 were tested as protectant fungicides against Cercospora leaf spot on sugar beets. The results concerning spore germination, fungicide tenacity, fungicide distribution, and fungicide particle size, indicate that the tin fungicide is a better protectant fungicide than either copper or maneb. No effort was made to determine whether the tin fungicide has any eradicative action.

The fungicide concentration required to inhibit spore germination was much higher on the leaf surface than on the glass slide, as one might expect, since on the glass slide the spore was bathed in the fungicide suspension; whereas on the leaf surface, the fungicide had to be solubilized in the spore suspension droplet.

Observations on fungicide particle size and particle clumping showed that the tin and copper fungicides had the smallest particle diameter, but only the tin showed no tendency to clump. Since the particle diameter for the tin and copper fungicides were nearly the same, it is unlikely that particle size alone could account for the difference in fungicidal distribution between the tin and copper. However, the tendency to avoid clumping may be responsible for some of the better distribution characteristics of the tin.

Evaluation of a Laboratory Method of Selecting Sugarbeets for Resistance to Storage Rot

D. L. Mumford, C. G. Filban, and G. J. Hogaboam

A laboratory method of selecting sugarbeets for resistance to storage rot is routinely used in breeding work in Russia (2)(personal communication with Mr. Dewey Stewart, 1965). Similar work involving inoculation techniques to test for resistance to storage pathogens has been reported in the United States (1). A laboratory method similar to one used by Russian workers was evaluated to determine its usefulness in our research program.

Competitive roots were harvested by hand from the field and washed. A rectangular section approximately 3 cm wide, 1 cm deep, and 5 cm long was removed from the side of each root. A special knife consisting of a flat blade with the edges turned up at right angles was used to remove the sections by passing it down the side of the root, beginning at the crown. Each section was cut in half and labeled to designate the beet it came from and the half originating nearest the crown. Up to 60 of these sections were placed in plates containing a culture of _Botrytis cinerea_ Fr.

Pyrex plates (22 x 22 cm) were poured with 300 ml of potato-dextrose-agar, then covered with aluminum foil and autoclaved. They were inoculated by spreading a spore suspension of the fungus on the agar surface. After four days, abundant fungal growth was present and the root sections were placed on edge directly on the culture surface. Following 10 - 14 days incubation at 21 - 23 C the sections were removed and examined by cutting them longitudinally and measuring the distance discoloration had progressed into the tissue. The value assigned each section was based on the number of mm the discoloration (rot) had moved into the tissue.

Rot Reaction of Roots Tested at Harvest and After Storage

Twenty roots of SP 6322-0, a pollinator used in the production of commercial hybrids for the Great Lakes Region, were rated by the laboratory method for storage rot resistance immediately after harvesting. After removing the sections for testing, these same roots were packed in wood shavings in crates and stored at 5° C. for one month. At the end of the storage period the roots were tested again, using a section from the opposite side of the root. Conditions during the second test were kept as

near as possible the same as the first test.

The mean value of 5.9 after storage was significantly higher ($p = 0.01$) than the mean value of 3.1 for the roots before storage. This indicates that during storage, even under relatively ideal conditions, changes take place in the roots which reduce their resistance to attack by the storage pathogen *B. cinerea*.

Evaluation of 25 Varieties and Strains for Resistance to Storage Rot

Ten roots of each variety were tested by the laboratory method, again using *B. cinerea* as the test organism. It is significant that the four varieties rated most resistant were from material that had undergone selection for *Botrytis* resistance by John Gaskill at Fort Collins, Colorado (Table 1). These results confirm the progress made at Fort Collins and suggest that the method employed here can be effectively used to select for resistance to storage rot caused by *B. cinerea*.

Table 1. Reaction of 25 varieties and strains of sugarbeet to storage rot by <u>Botrytis cinerea</u>

Identification No.	Description a/	Average mm of Rot
SP 641203Ho	mm; SBR	1.9
SP 571801-00	MM; SBR from SP 50A3-00	2.0
SP 571102-00	MM; SBR from SP 50A3-00	2.5
SP 581026-0	MM; SBR from US 400	2.7
US 401	MM; Susceptible to <u>Rhizoctonia</u>	2.7
US 400	MM; Susceptible to <u>Botrytis</u>	2.8
GW 674-56C	MM; Great Western Sugar Co. - susc. to <u>Rhiz.</u>	3.0
EL 33	mm; Inbred from East Lansing	3.2
SP 581027-0	MM; SBR from US 400	3.2
SP 581025-0	MM; SBR from US 400	3.2
64G4-02	M-; Susceptible to <u>Rhizoctonia</u> - East Lansing	3.2
SP 621003-0	M-; SRR	3.4
SP 5831-0	mm; Susceptible to <u>Rhizoctonia</u> - Ft. Collins	3.6
SP 633700-1	mm; Resistant to <u>Aphanomyces</u> - Beltsville	3.7
SP 621004-0	mm; SRR from SP 5831-0	3.8
US 225	MM; Inbred susceptible to <u>Botrytis</u>	3.8
SP 633667-1	mm; Susceptible to <u>Aphanomyces</u> - Beltsville	3.8
EL 31	mm; Inbred from East Lansing	4.2
SP 631001-0	MM; SRR from Gw 674-56C	4.6
SP 50A3-00	MM; Susceptible to <u>Botrytis</u> - Fort Collins	4.7
F59-507H1	mm; Susceptible to <u>Aphanomyces</u> - Salinas	4.8
64G4-01	M-; Susceptible to <u>Rhizoctonia</u> - East Lansing	5.3
EL 34	mm; Inbred from East Lansing	5.4
EL 32	mm; Inbred from East Lansing	6.5
EL 35	mm; Inbred from East Lansing	6.7
	LSD 5%	1.9

a/ MM = Multigerm
M- = Multigerm - female plant
mm = Monogerm
SBR= Selection made for <u>Botrytis</u> resistance at Fort Collins
SRR= Selection made for <u>Rhyzoctonia</u> resistance at Fort Collins

Selection of Resistant Roots from SP 6322-0

One thousand roots of SP 6322-0 were tested with the laboratory method. Some difficulty arose in testing this material because the plates containing the sections were incubated for 28 days. It is suspected that the longer incubation time allowed contaminants carried on the sections to grow and influence the ratings. This led to reducing the incubation time to 10 - 14 days.

A 100-root sample was selected from those receiving the lowest storage rot rating, and another 100-root sample was selected from those receiving the highest rating. Progenies from these two samples will be compared. By making these selections from the pollinator currently being used commercially, any significant improvement observed in the resistant sample could rapidly be incorporated into commercial use.

Comparison of Beets Grown at Three Nitrogen Levels

Root samples from plots receiving high, medium, and low levels of nitrogen fertilization were tested with the laboratory method. These roots were obtained from fertilization experiments being carried out by F. W. Snyder and Grant Nichol in the Thumb Area of Michigan. Three replications from each of the three nitrogen levels were tested from each of four locations. Although the specific levels of nitrogen applied varied between locations, there was at least a 30 lb. difference between the low and medium levels and at least a 90 lb. difference between the low and high levels.

Reaction to B. cinerea and analysis for sugar content, purity, amino nitrogen, and potassium were determined on the same 10-root samples. Based on a combined analysis of variance for four locations, there was significantly ($p = .05$) less rot of root sections from the high nitrogen level than from the medium and significantly less rot of root sections from the medium than from the low nitrogen level (Table 2). Although both average total rot and percent sugar increased with a decrease in nitrogen level at each location, the correlation (0.18) based on individual samples was not significant. The highest correlation (-0.68) occurred between rot and amount of amino nitrogen. This is in agreement with a report by Russian workers (2) that roots with low nitrogen content were more severely affected than those with high nitrogen content.

The data presented suggest that roots with high purity and low nitrogen are more susceptible to rot by B. cinerea. Since it is generally accepted that storage losses are less in high quality roots, it would seem that factors other than rot by B. cinerea are of major importance in causing losses in stored beets.

Table 2. Storage rot reaction, sugar content, clear juice purity (CJP), amino nitrogen level (NH_2-N), and potassium level (K) of roots grown at three levels of nitrogen fertilization a/

Location	Nitrogen Level	Average Total Rot	Sugar in Beet	CJP	NH_2-N per 100 g. Sugar	K/100 g. Clear Juice
	Lbs.	mm	%	%	mg.	mg.
1	High (180)	100 b/	13.6	93.6	253	176
	Medium (120)	102	14.0	93.5	228	178
	Low (60)	117	15.2	94.6	166	160
2	High (120)	98	14.6	92.5	308	169
	Medium (60)	101	15.0	92.9	319	190
	Low (30)	108	15.2	93.3	283	180
3	High (150)	106	14.2	93.5	253	174
	Medium (90)	127	14.8	94.2	168	173
	Low (30)	141	15.1	94.7	123	187
4	High (180)	84	15.2	93.5	293	133
	Medium (90)	102	15.8	93.9	221	133
	Low (30)	109	16.8	95.7	171	129
Correlation with rot (based on individual plots)			0.18	0.56	-0.68	-0.28

a/ Data on sugar content, CJP, NH_2-N, and K were supplied by F. W. Snyder

b/ Each figure represents an average of three replications of 10 roots. Based on a combined analysis of variance for four locations, there was significantly ($p = .05$) less rot of root sections from the high nitrogen level than from the medium and significantly less rot of root sections from the medium than from the low nitrogen level.

Conclusion

The laboratory method employed can be used to identify sugarbeet roots that are more resistant to the storage pathogen Botrytis cinerea. The advantages of this method are that it requires a minimum of time and space, can be accomplished in controlled conditions, and does not require sacrificing the roots tested.

Evidence has been obtained that during storage changes take place in roots which reduce their resistance to B. cinerea. Additional evidence indicates that nitrogen fertilization practices can influence the reaction of roots to B. cinerea.

Before a major breeding effort utilizing this method could be justified, it would be necessary to obtain information on other questions. First, information is needed on the amount of losses in stored beets directly attributable to storage pathogens or other microorganisms. If microorganisms are a significant factor, then it would be important to know which ones were involved; and this might vary with location and season. Also, it would be important to know whether B. cinerea is a suitable test organism or whether selection would have to be made for each of several organisms causing loss.

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PART XIII

VIRUS DISEASES

Transmission of Beet Western Yellows Virus
by Aphids Feeding Through a Membrane[1/]

J. E. Duffus and A. H. Gold

- - -

Effects of Phenol on the Inhibition of Cucumber
Mosaic Virus in Extracts from Sugarbeet[2/]

E. G. Ruppel

Cooperation:

[1/] University of California

[2/] University of Arizona

Transmission of Beet Western Yellows Virus by Aphids Feeding through a Membrane

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Green peach aphids, Myzus persicae (Sulzer), successfully acquired beet western yellows virus from a juice extract when fed through an artificial membrane. Aphids were fed on crude, concentrated, and density-gradient fractions prepared from beet western yellows virus-infected radish (Raphanus sativus L.). Groups of 10 aphids, transferred from the membranes to healthy shepherd's-purse, Capsella bursa-pastoris (L.) Medic. seedlings, transmitted the virus to 2.8%, 12.1%, and 89.7% of the plants, respectively. Infectivity was greatly increased by passage through a density gradient and appeared to be associated with one fraction in the tubes. Efforts to concentrate beet western yellows virus by differential centrifugation appears to be promising.

INTRODUCTION

An important factor in developing purification methods for plant viruses is the ability to assay for infectivity. A major group of important plant viruses, the persistent or circulative aphid-transmitted viruses, of which beet western yellows virus is a member, are in general not mechanically transmissible. Two different assay techniques, membrane feeding and direct injection of vectors, have been effectively used to test infectivity of preparations of this type of virus. A membrane feeding technique, developed by Carter (1928) and modified by others, has been successfully used with a persistent aphid-transmitted virus, barley yellow dwarf (Rochow, 1960), and a stylet-borne virus, alfalfa mosaic virus (Pirone, 1964).

The successful application of the membrane feeding technique to beet western yellows virus is reported in this paper.

MATERIALS AND METHODS

Nonviruliferous green peach aphids, Myzus persicae (Sulzer), were reared on radish (Raphanus sativus L.).

Strains of beet western yellows virus obtained from various host plants (Duffus, 1964) were maintained on radish and sugarbeet (Beta vulgaris L.).

Feeding cages were made from screw cap glass vials, 26 mm in diameter. The bottoms of the vials were cut off and the edges fire polished, leaving a capped tube approximately 5 cm long. The polished end of the vial was capped with a thin membrane of Parafilm (Marathon Corporation, Menasha, Wisconsin). Groups of 40-50 nonviruliferous green peach aphids were placed in these cages. Approximately 0.1 ml of the liquid extract to be tested was placed on the membrane and covered with another thin membrane of parafilm. Cages with aphids and liquid extract were then placed in holes drilled in wooden blocks, membrane side up, for ease in handling. After a 24-hour acquisition feeding period at 20°-26°C and under continuous light, the screw cap was removed from the vials and the aphids were transferred in groups of 10 to shepherd's-purse, Capsella bursa-pastoris (L.) Medic. seedlings. The seedlings were caged individually and the aphids left for a 48-hour infection feeding. Other aphids from each colony used in membrane feeding experiments were put on at least 6 healthy shepherd's-purse seedlings for 72 hours simultaneously with each membrane feeding test. In no instances, during the course of these studies, were viruliferous aphids found in the stock aphid colonies.

Most extracts for feeding were prepared from radish plants infected with various strains of the beet western yellows virus. Frozen leaf tissue was partially thawed and ground in a food grinder with dry 2% Na_2HPO_4 and 0.02% ascorbic acid. Crude extracts were clarified by low speed centrifugation (10 minutes at 8,000 rpm, 4221 g) in the No. 40 rotor of a Spinco Model L ultracentrifuge. In some experiments, clarified juice was then centrifuged for 2 hours at 35,000 rpm (80,801 g). Pellets were usually left overnight at 4°C in 0.5 ml of 0.05 M phosphate buffer, pH 7.0, containing 0.01 M glycine. Pellets were resuspended with a stirring rod. Resuspending pellets in 0.5 ml of buffer represented a 33-fold increase in concentration. These extracts are referred to as 33X concentration.

In tests in which a concentration greater than 33X was desired, resuspended pellets were combined, cleared at 8,000 rpm (4221 g) for 10 minutes and again pelleted at 35,000 rpm (80,801 g) for 2 hours and resuspended in an appropriate volume of buffer.

Density-gradient centrifugation was done in a SW-39 rotor for 2 hours at 30,000 rpm (73,449 g). Gradient columns were prepared by layering 0.9 ml each of 20, 30, 40, 50, and 60% sucrose dissolved in 0.05 M phosphate buffer, pH 7.0, containing 0.01 M glycine. Samples were removed from the gradient columns by means of a J-shaped hypodermic needle inserted from the top.

Sucrose was added to all feeding extracts, except density-gradient preparations, to make a concentration of 30% just before they were placed on the membranes.

RESULTS

Early attempts to transmit beet western yellows virus by membrane feeding techniques involved crude juice extracts or extracts clarified by low-speed centrifugation. In 18 tests, 8 of 289 plants (2.8%) became infected. There was no infection in most tests and a maximum transmission of 23% in any 1 test. This transmission was much lower than the 54% transmission obtained by Rochow (1960) with the barley yellow dwarf virus and the English grain aphid, Macrosiphum granarium (Kirby), with similarly prepared plant extracts.

In attempting to increase the transmission percentages, efforts were made to concentrate beet western yellows virus by ultracentrifugation. In 10 tests with virus concentrations 33 to 333 times that of crude extracts, 24 of 198 plants (12.1%) became infected. Some transmission occurred in each of 6 tests but none in the other 4. The maximum transmission percentage in any test was 30%.

In a preliminary test of density-gradient centrifugation, 1 ml of clarified and 1 ml of a preparation concentrated 33 times were floated on density-gradient tubes to determine whether this technique would be of value in membrane feeding and purification procedures. The results (Table 1) indicate that infectivity of an extract was greatly increased by passage through a density-gradient. Also, infectivity apparently was associated with a zone in the tubes between 17 and 31 mm from the top of the tube. Apparently the high speed centrifugation had concentrated the virus, which resulted in increased transmission. In 8 subsequent tests using density-gradient centrifugation with preparations of 33X, 245 of 273 plants (89.7%) became infected.

A trial was run to determine the combined effects of high speed centrifugation and density-gradient centrifugation on suitability of preparations for feeding aphids through membranes. The results (Table 2) indicate that the virus had been concentrated by high speed centrifugation and that the transmissibility by aphids was greatly increased upon further purification by density-gradient centrifugation.

DISCUSSION

The application of a membrane feeding technique to beet western yellows virus may facilitate further characterization of this and other persistent or circulative aphid-transmitted viruses. A similar technique with barley yellow dwarf virus (Rochow and Brakke, 1964) has already aided in purification of this virus.

It would appear from the greatly improved transmission efficiency when the aphid feeding extracts were run through a density-gradient (12.1% transmission as compared to 89.7%) that substances that inhibit

aphid transmission occurred in expressed radish juice. These substances, which are apparently separated from the virus by density-gradient centrifugation, may be at least a partial answer to the question raised by Rochow (1960), as to why attempts to transmit plant viruses by membrane feeding techniques have generally failed. The possibility exists, however, that aphid feeding on crude extracts and density-gradient fractions is different and may account for the marked differences in transmission, although if this is so, the feeding differences are not always obvious.

The membrane feeding technique is being used in attempts to explain the apparent inhibitory effects of expressed radish juice on beet western yellows virus transmission, to characterize the virus further and as an aid in devising methods for its purification.

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TABLE 1

Infectivity of Beet Western Yellows Virus in Fractions Obtained after Density-Gradient Centrifugation.

Depth of fraction (mm) from the top	Appearance of zones	Infectivity[a]	
		1X	33X
0-10	Slightly turbid	0/14	0/6
10-17	Turbid	0/8	0/10
17-25	Turbid	3/16	8/9
25-31	Clear	1/12	6/8
31-35	Turbid	0/10	0/6
35-41	Clear	0/8	0/8
Uncentrifuged preparation	Turbid	0/8	0/8

[a]Numerator indicates the number of plants infected, and the denominator the number of plants inoculated by 10 green peach aphids fed through a membrane on each fraction. 1X sample was sap cleared by low speed centrifugation, 33X sample was cleared by low speed centrifugation and pelleted by ultracentrifugation. Pellets were resuspended in 1/33 of the original volume.

TABLE 2

Infectivity of Beet Western Yellows Virus Extracts Before and After Density-Gradient Centrifugation.

Sample tested	Infectivity of sample at indicated relative concentration[a]	
	1X[b]	330X[c]
Preparations before density-gradient centrifugation	$\frac{0}{20}$	$\frac{3}{20}$
Virus zone removed from density-gradient tube[d]	$\frac{7}{40}$	$\frac{119}{120}$

[a]Numerator indicates the number of plants infected and the denominator the number of plants inoculated by 10 green peach aphids fed through membranes on the samples.

[b]1X sample was sap cleared by low speed centrifugation.

[c]330X sample was cleared by low speed centrifugation and pelleted by ultracentrifugation. Pellets were resuspended in 1/330 of the original volume.

[d]Virus zone obtained from 17-25 mm from the top of the tube.

EFFECT OF PHENOL ON THE INHIBITION OF CUCUMBER MOSAIC VIRUS IN EXTRACTS FROM SUGARBEET

E. G. Ruppel

Preliminary efforts to transmit cucumber mosaic virus (CMV) mechanically from infected to healthy sugarbeets or to other hosts of CMV failed. In all attempts only local chlorotic spots developed in the inoculated leaves of sugarbeet without systemic invasion by the virus. It has been shown that phenol-buffer extractions from CMV-infected *Nicotiana glutinosa* L. or *Cucumis sativus* L. yielded an inoculum preparation that was considerably more infectious than buffer extractions alone (1). Similar results are reported with CMV-infected tobacco leaves as the source of CMV inoculum (2, 4). Francki (1) presented evidence that the phenol extraction procedure removed an inhibitor of CMV in the plant sap. The study reported herein was conducted to determine whether phenol extractions could facilitate the mechanical transmission of CMV from sugarbeet.

METHODS AND MATERIALS

An isolate of CMV was obtained from a diseased sugarbeet plant growing at the University of Arizona Mesa Experiment Station. The isolate was transmitted to healthy sugarbeet seedlings in the greenhouse with green peach aphids (*Myzus persicae* (Sulz.)). A 1-minute acquisition feeding followed by a 1-minute transmission feeding effected the transmission.

The procedure for making extractions was essentially the same as that used by Francki (1). Buffer extracts were prepared by grinding 2 g of CMV-infected sugarbeet leaf tissue in 4 ml of 0.1 M phosphate buffer, pH 7.2, with a mortar and pestle. The homogenates were strained through cheesecloth and centrifuged for 5 minutes at 3000 rpm. Phenol-buffer extracts were prepared by grinding 2 g leaf tissue in 2 ml buffer and 2 ml water-saturated phenol. Homogenates were strained and centrifuged as above. Buffer layers were withdrawn with a hypodermic syringe and washed in about 10 volumes of ether. In one experiment, buffer extracts from diseased tissue were made as above; these extracts were washed in about 10 volumes of ether.

Inoculations were made to Carborundum-dusted leaves of *Beta vulgaris* L. 'S301-H' or *Vigna sinensis* (Torner) Savi 'Black' with inoculum-saturated cheesecloth pads. Leaves were rinsed with distilled water 3-6 minutes after inoculation. Laboratory operations were performed at room temperature, whereas greenhouse temperatures varied between 18-27° C. Supplemental fluorescent lights were kept on at night in the greenhouse.

RESULTS

Transmission of CMV from Sugarbeet to Sugarbeet

Twenty 2-month-old sugarbeet seedlings were inoculated with a buffer extract from CMV-infected sugarbeet leaf tissue. An additional 20 plants were inoculated with a phenol-buffer extract from the same CMV source plant. One of 20 plants inoculated with the buffer extract developed local chlorotic spots on the inoculated leaves. The virus did not become systemic over a period of 60 days at which time the plants were discarded. All plants inoculated with the phenol-buffer extract developed abundant local chlorotic spots. Furthermore, systemic invasion by CMV was evident in 6 of the 20 plants.

Transmission of CMV from Sugarbeet to Cowpea

In a second experiment cowpea was used as a local lesion host for infectivity tests. Inocula consisted of 1) a buffer extract from CMV-infected sugarbeet, 2) a phenol-buffer extract from infected sugarbeet, 3) buffer, and 4) buffer that had been mixed with water-saturated phenol and washed in ether. Inocula 1 and 2 were rubbed on the primary leaves of six cowpea seedlings, whereas 3 and 4 were rubbed on the primary leaves of only four seedlings each.

Results were recorded 4 days after inoculation. No lesions were induced by treatments 1, 3, or 4. Treatment 2, however, induced an average of 133 lesions per leaf.

The Role of Ether in Phenol-Buffer Extractions

It seemed conceivable that the ether washes of the phenol-buffer homogenates could be responsible for the removal of the inhibitor to CMV in sap extracts. To determine the role of the ether, the infectivity in cowpea of a buffer extract washed with ether and a phenol-buffer extract washed with ether were compared. A comparison also was made between leaves inoculated with the phenol-buffer extract and immediately rinsed, and leaves inoculated with the same extract and not rinsed. Since phenol is extremely deleterious to plants, phenol-buffer extracts always had to be washed with ether to remove the phenol. A 3 x 3 Latin square design was used. Because of the danger of cross contamination by rinsing, the half-leaf method was not employed.

Results indicated that the role of ether in the removal of the CMV inhibitor from beet sap was relatively unimportant. The ether-washed buffer extract only induced an average of 3 local lesions per leaf, whereas the phenol-buffer extract followed by rinsing induced an average of 398 lesions per leaf. The leaves inoculated with the phenol-buffer extract

without rinsing developed an average of 404 lesions per leaf, but the difference between this treatment and the treatment followed by a rinse was not significant.

Effect of Dilution on Infectivity of Sugarbeet Extracts

Concentrated sap extracted from CMV-infected sugarbeet was diluted 1:10, 1:100, 1:1000, and 1:10,000 with 0.1 M phosphate buffer, pH 7.2. The half-leaf method was employed to inoculate primary leaves of cowpea. Six replications were used in a complete randomized block design.

Infectivity of all dilutions was extremely low. Inoculation with the 1:10 dilution produced a half-leaf average of only 3.7 local lesions. Those with the 1:100, 1:1000, and 1:10,000 produced averages of 1.3, 0.8, and 2.8 lesions, respectively. Differences in lesion numbers were not significant.

DISCUSSION

This study did not serve to determine the identity or nature of the inhibitory effect against CMV present in sugarbeet extracts. But the results did indicate that such an effect exists and can be efficiently removed or reduced by extracting CMV with phenol.

The role played by the ether in the phenol-buffer extractions apparently is unimportant in regard to the removal of the inhibitory action of the sap. The ether simply serves to remove the deleterious phenol from the buffer extract.

Slightly more lesions were induced in cowpea when phenol-buffer inocula were not rinsed from the leaves after inoculation. However, since severe damage occurred on some leaves rinsing is recommended.

Dilution of buffer extracts did not remove the inhibitory effect to any great extent. However, some lesions did develop in cowpea with the highest dilution (1:10,000) producing almost as many lesions as the 1:10 dilution. Dilution apparently had more effect on the inhibitor(s) than it did on the virus.

Sugarbeet sap has been reported to contain an inhibitor to beet mosaic virus (BMV) (5). However, the BMV inhibitor and most inhibitors from higher plants (3) usually have little effect in preventing infection of the host species that contain them. The CMV inhibitor in sugarbeet extracts, however, prevented systemic infection of sugarbeet and other known hosts.

The development of local chlorotic infections without systemic spread of CMV is not understood. Even when phenol extracts were used only 30% systemic infection was obtained, whereas 100% of the plants exhibited the chlorotic spots.

The use of phenol-buffer provides a more efficient medium than buffer alone for extracting CMV from infected sugarbeet tissue. The method should facilitate research studies with this host-virus combination.

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PART XIV

PHYSIOLOGICAL INVESTIGATIONS

- - -

QUALITY

- - -

SEED GERMINATION

F. W. Snyder

Research conducted in cooperation with the Michigan Agricultural Experiment Station and with the Farmers and Manufacturers Beet Sugar Association.

PHYSIOLOGICAL INVESTIGATIONS - 1965 1/

F. W. Snyder

Germination Studies 2/

The effects of ripeness of fruits and seeds on germination performance of sugarbeet variety AI 1 x AI 2 which were included in the 1964 report have been confirmed for the variety GW 823; namely, slower and less complete germination as fruits are harvested prior to maturity.

Quality Studies - 1964

More of the data collected in the cooperative studies mentioned in the 1964 report follow. The correlation coefficients (Table 1) for 1964 data are based on more than 500 samples, with the exception of the betaine data which are based on about 170 samples. Although most of the correlations are significant at the 1% level, they are not very good, particularly when the correlation coefficients are squared and examined as the coefficients of determination.

The quantity of impurities accounted for in four tests (Table 2) varies surprisingly. Possibly the location or field plays a role in this. If instead of reporting the data as percentages they are expressed as impurity units by multiplying by the factors suggested by Carruthers and Oldfield 3/, many of the summated values for the Walraven experiment are greater than the total impurities indicated by the clear juice purity. A number of the Woodslee Plant spacing - Nitrogen values also were greater. This suggests that for the Michigan and Ontario beet growing areas, Carruthers and Oldfield constants are too large, at least in certain areas.

Quality Studies - 1965

The data from four nitrogen fertilization experiments are similar to those reported in 1964. Two tests are listed in Table 3. Weather conditions apparently produced lower sugar content coupled with high

1/ Research conducted in cooperation with Michigan Agricultural Experiment Station.

2/ Samples of seed were supplied by West Coast Beet Seed Company, Western Seed Production Corporation, and Farmers and Manufacturers Beet Sugar Association.

3/ Carruthers, A., and Oldfield, J.F.T., The Technological Value of the Sugar Beet, "Methods for the Assessment of Beet Quality," Elsevier Publishing Company, New York, 1962, pp. 224 - 248.

clear juice purity. The impurity data (Table 4) are expressed as Carruthers and Oldfield did in order to compare directly with the 1964 data.

Sufficient data have been accumulated in Michigan over the past few years to indicate clearly that applications of nitrogen in excess of 90 pounds per acre fail to give a yield response and that the recoverable sugar per ton,as well as per acre, are decreased.

Table 1. Correlation data for 1964 quality study in eastern sugarbeet area (Michigan, Ohio, Ontario)

	Impurities	C.J.P.	Amino-N	Potassium	Sum Amino-N Potassium Sodium	Sum Amino-N Potassium Sodium Betaine	Betaine
Sugar in beet	-0.69**	+0.68**	-0.65**	-0.61**	-0.70**	-0.60**	-0.34**
C.J.P			-0.85**	-0.75**	-0.89**	-0.90**	-0.50**
Amino-N * (Moore & Stein)				+0.65**	+0.98**	+0.97**	+0.61**
Potassium *					+0.81**	+0.79**	+0.44**
Sodium *						+0.54**	+0.08

* Analyses on clear juice

Table 2. Impurities accounted for in analysis of clear juice in 1964 quality study in eastern sugarbeet area

Location	Type Experiment	Range Appar. Impur.	Range in Percentage of Impurity: Amino-N x 9.5	K	Na	Betaine	Sum 4 impur.
Appold*	Nitrogen	5717 8734	18.2 31.6	14.7 16.3	1.1 2.3	12.3 15.4	50.5 60.8
Walraven*	Nitrogen	5737 11375	37.4 47.3	11.5 15.2	0.4 0.7	17.6 25.9	73.2 79.1
Woodslee**	Row width - plant spacing	9824 12269	30.6 35.7	16.1 17.4	1.4 1.8	16.0 18.5	64.5 72.6
Woodslee**	Plant spacing - nitrogen	4369 7445	17.0 30.7	15.8 19.8	0.3 1.0	22.0 30.1	64.3 69.3

* Bay City, Michigan
** Ontario, Canada

Table 3. Effect of nitrogen on yield and quality of sugarbeets grown near Bay City, Michigan. Variety (SL126x128)ms X SP5822-0

EISENMAN NITROGEN TEST

Total N* per Acre	Beets/ 100 Ft.	Wt.** T/A	Sugar %	CJP	Gross Sug./A	Recov. Sug./A	% Recov.	Recov. Sug./T
30	88	21.88	16.8	95.6	7352	6665	90.7	304.6
60	89	21.18	15.9	94.8	6735	6002	89.1	283.4
90	89	22.13	15.8	93.9	6993	6117	87.5	276.4
120	89	21.17	15.3	93.8	6478	5652	87.2	267.0
150	96	21.66	14.4	92.8	6238	5320	85.3	245.6
180	88	22.09	15.2	93.5	6715	5819	86.7	263.4

WALRAVEN NITROGEN TEST

Total N* per Acre	Beets/ 100 Ft.	Wt.** T/A	Sugar %	CJP	Gross Sug./A	Recov. Sug./A	% Recov.	Recov. Sug./T
30	90	20.08	15.1	94.7	6064	5389	88.9	268.4
60	94	19.52	14.5	94.1	5661	4966	87.7	254.4
90	96	19.55	14.8	94.2	5787	5087	87.9	260.2
120	101	19.43	14.4	93.0	5596	4791	85.6	246.6
150	93	19.80	14.2	93.5	5623	4867	86.6	245.8

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* 30 lbs. at planting time, rest as side dress
** Corrected for 10% tare.

Table 4. Impurity values* for same two nitrogen fertilization experimental tests in 1965 cited in Table 3

Lbs. N per Acre	Impurity values for each impurity by location: Amino nitrogen		Potassium		Sodium	
	Eisen.	Walraven	Eisen.	Walraven	Eisen.	Walraven
30	1830	1310	1930	3132	221	686
60	2040	1980	2118	3505	343	861
90	2350	1770	2183	3043	417	756
120	3230	2220	2498	3373	480	1001
150	2800	2680	2455	3165	683	784

*Based on averages of 3 replications and calculated by method of Carruthers and Oldfield. Analyses made on clear juice.

PART XV

BREEDING FOR RESISTANCE TO LEAF SPOT AND BLACK ROOT

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RELATIVE LEAF SPOT DAMAGE ON RESISTANT VARIETIES

G. E. Coe

The research was supported in part by funds provided through the Beet Sugar Development Foundation (Project 26).

DEVELOPMENT OF BREEDING MATERIAL RESISTANT TO LEAF SPOT AND BLACK ROOT

G. E. Coe

Research under Foundation Project 26 at the Plant Industry Station, Beltsville, Maryland, is directed mainly toward varietal improvement in resistance to Cercospora leaf spot and Aphanomyces black root. This program contributes to the synthesis of many varieties and hybrids evaluated in field tests reported in Part XI.

The results reported in this Part cover trends in the performance of basic breeding material, leaf spot resistance of some new O-type and MS lines, a discovery related to the greenhouse black root testing program, and a Cercospora fungicide spray test to appraise damage resistance.

Improvement in Basic Breeding Stocks

Graphs 1 through 8 show the trends in disease resistance and agronomic characteristics and compare the performance of multigerm and monogerm breeding lines with the performance of US 401. US 401 is given a numerical value of 100. The average performance of all the breeding lines is compared with the performance of US 401. Thus, ratings above 100 indicate that the lines performed better than US 401, and those below 100 indicate that they did not perform as well. In percentage nonsugar solutes, ratings above 100 indicate better performance; hence, a lower percentage of nonsugar solutes.

Compared with 1964, Graphs 1 and 2 indicate an apparent decline in the degree of leaf spot tolerance of the breeding lines. This should not be interpreted as a decline in the inherent resistance of the lines. It can be explained by the year-to-year variation in the relative performance of US 401, attributable to the degree of severity of the leaf spot epidemic. The long-term trend of the graphs indicate improvement in leaf spot tolerance of 2 or 3 percentage points each year.

Graphs 1 and 2 also depict the trends in tolerance to the black root organism, Aphanomyces cochlioides Drechs. However, there is reason to believe that these trends to not reflect all the heritable improvement. The relative performance of tolerant varieties of sugarbeet is better when black root is not too severe. Because of increased black root resistance of the breeding lines, it has been necessary to increase the dosage of inoculum every 2 or 3 years. This changes the base for comparison, and the increase in tolerance to black root appears smaller than if the disease severity had not been increased.

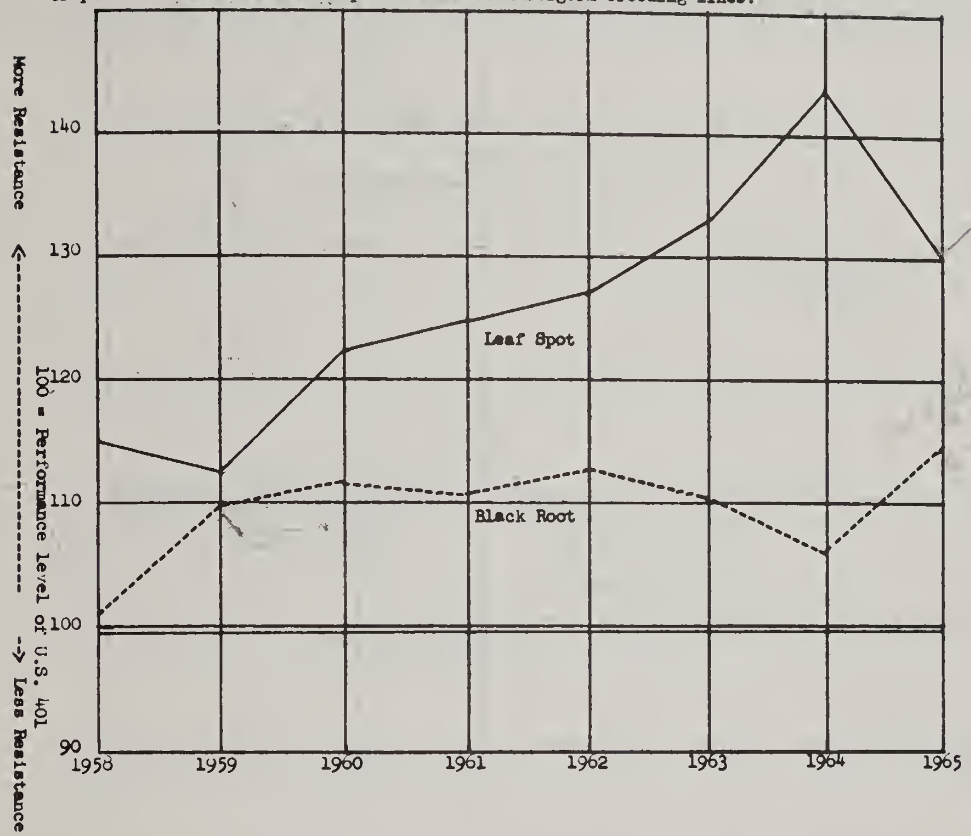
The black root resistance of progenies of plants selected from black root tests conducted in the greenhouse is particularly encouraging. Progenies of multigerm plants selected for black root tolerance had an average performance rating of 123 as compared with a performance rating of 110 for progenies of field selected plants. The performance rating of progenies of monogerm plants selected from the black root test was 117, whereas the performance ratings for the progenies of field selected monogerm plants was 106.

In comparison with US 401, the root yield of both the monogerm and the multigerm breeding stock appeared to be relatively lower at Beltsville in 1965 than in 1964 (Graphs 3 and 4). The root yields are still considerably higher than that of US 401, but the increased yield at Beltsville undoubtedly is related to better disease resistance and does not indicate inherent yield potential. Tests at other locations indicate no increase in yield over the standard check variety. Beltsville selections for greater yield probably have been neutralized by intense selection pressure for other desired characteristics.

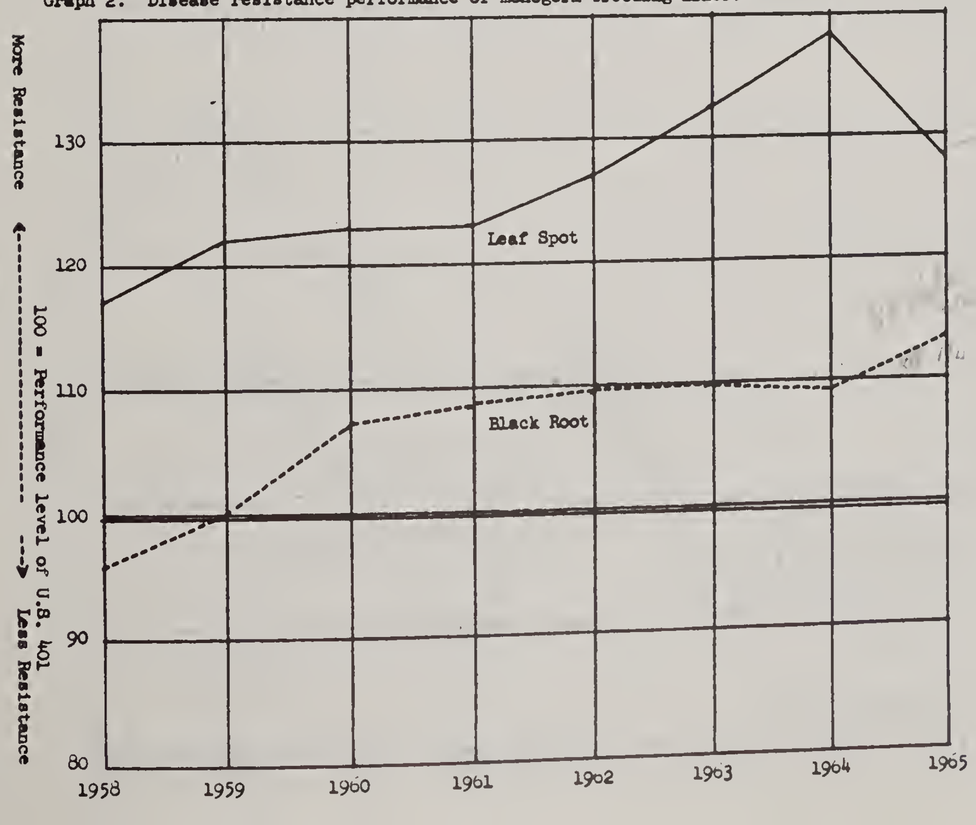
Graphs 5 and 6 indicate only slight improvement in sugar percentage in basic breeding stocks. High sugar selections at Beltsville are restricted by the requirement that there must be no apparent sacrifice in root yield. Sugar percentages higher than that for US 401 at Beltsville are associated with better resistance to leaf spot. Efforts to improve sugar percentage of monogerm sorts appear only to have prevented a decline in inherent sugar percentage,as selection pressure was being applied to improve other characteristics.

Graphs 7 and 8 depict the trend in the performance of breeding lines in content of nonsugar solutes. For 4 years, the multigerm breeding stocks have had less of these undesirable solutes than US 401, but improvement in this characteristic progresses at a slow pace. Improvement of this characteristic in the monogerm breeding stocks has been more rapid, but probably only because they contained appreciably more nonsugar solutes when selection and crossing to improve this characteristic were initiated.

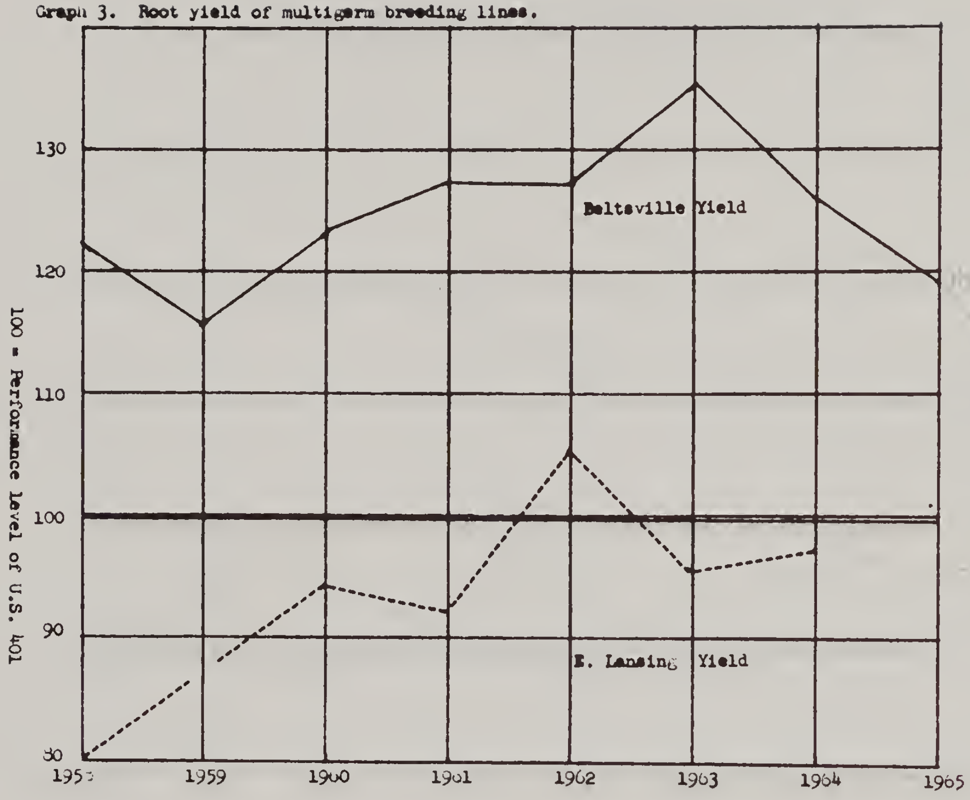
Graph 1. Disease resistance performance of multigerm breeding lines.



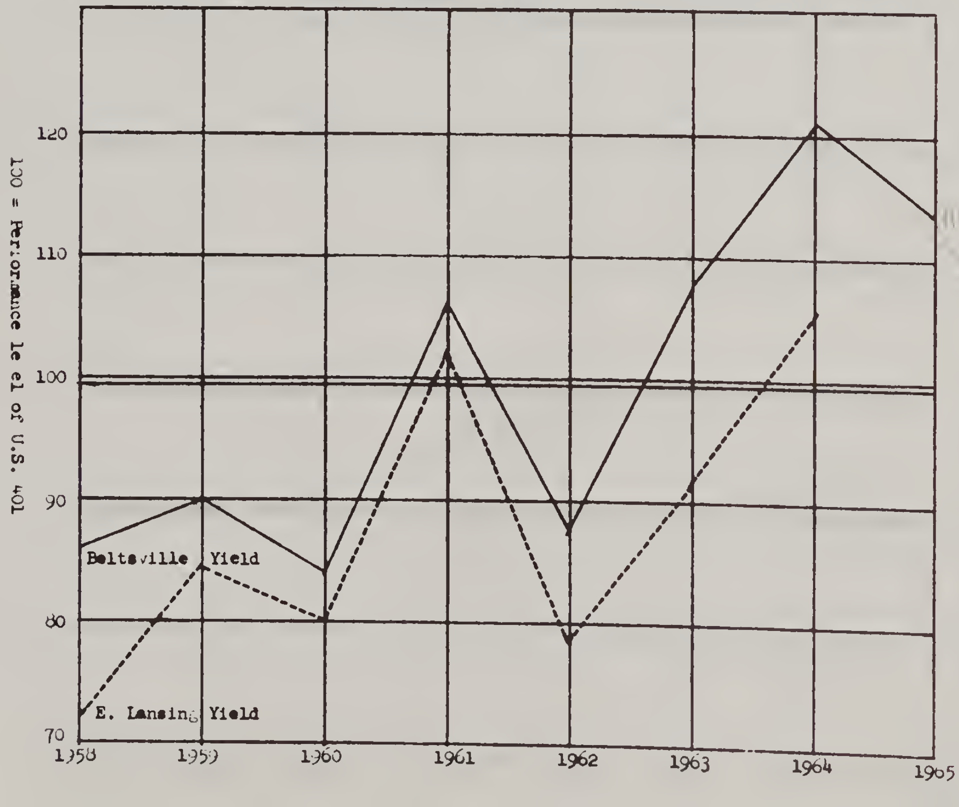
Graph 2. Disease resistance performance of monogerm breeding lines.



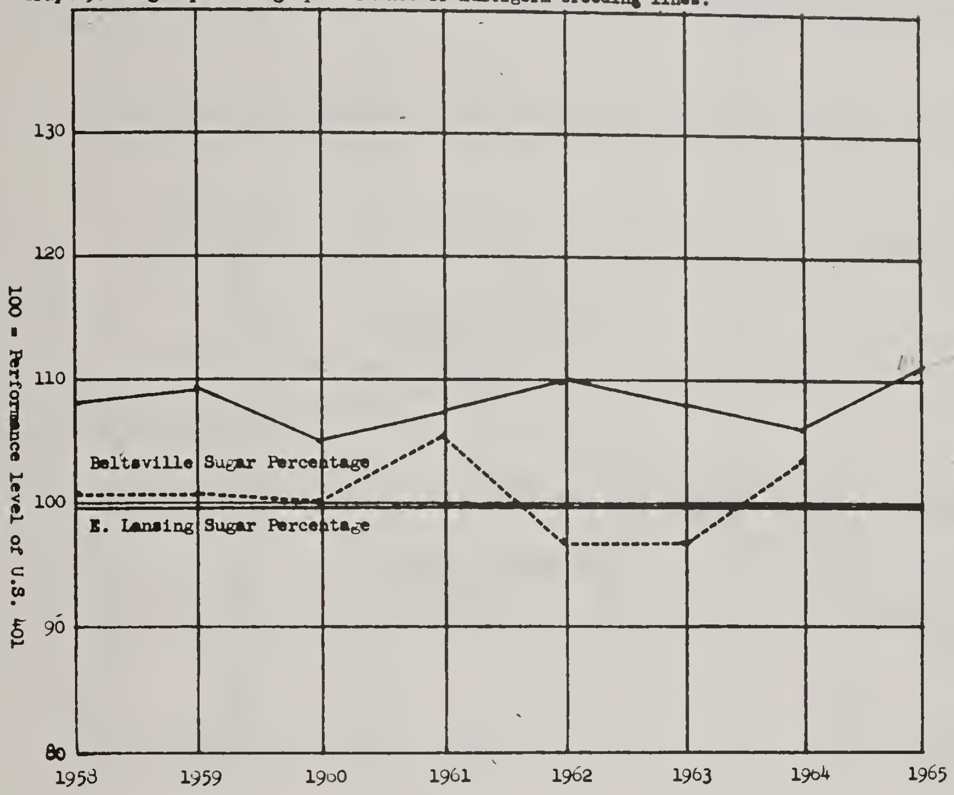
Graph 3. Root yield of multigerm breeding lines.



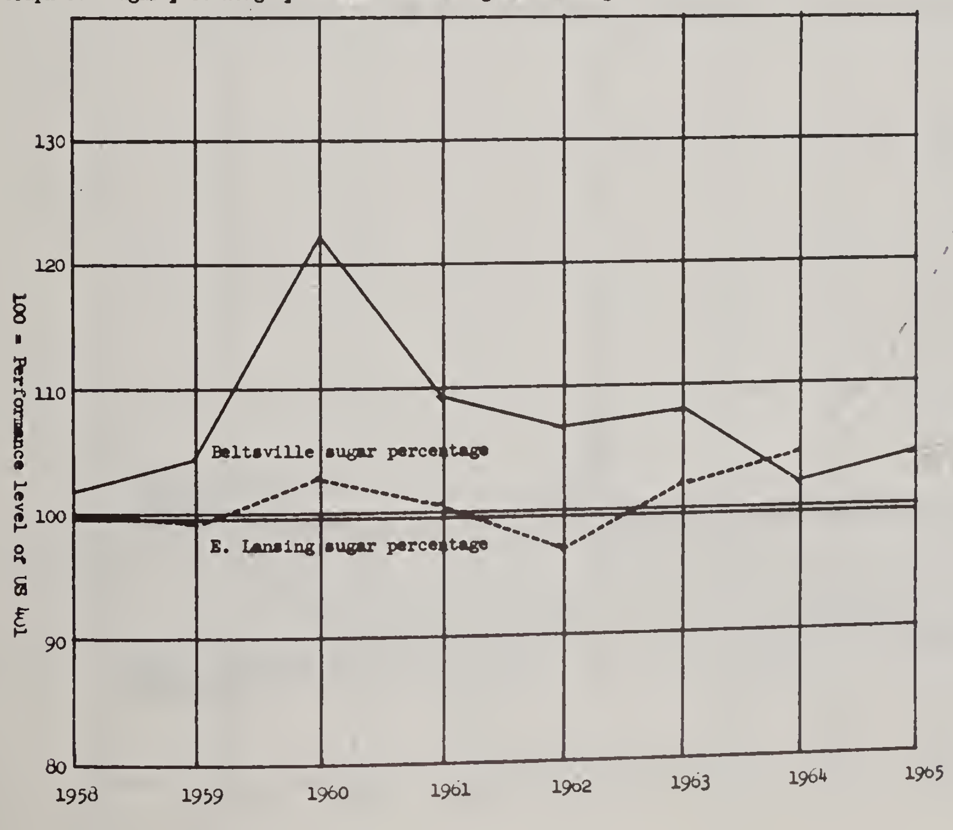
Graph 4. Root yield of monogerm breeding lines.



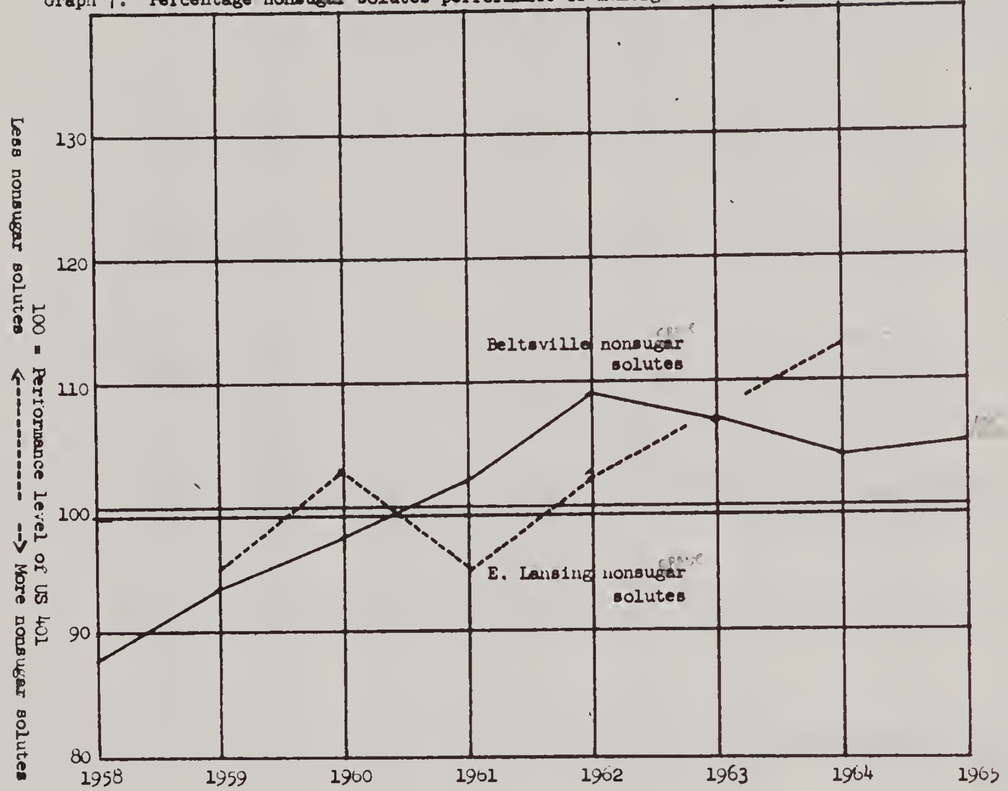
Graph 5. Sugar percentage performance of multigerm breeding lines.



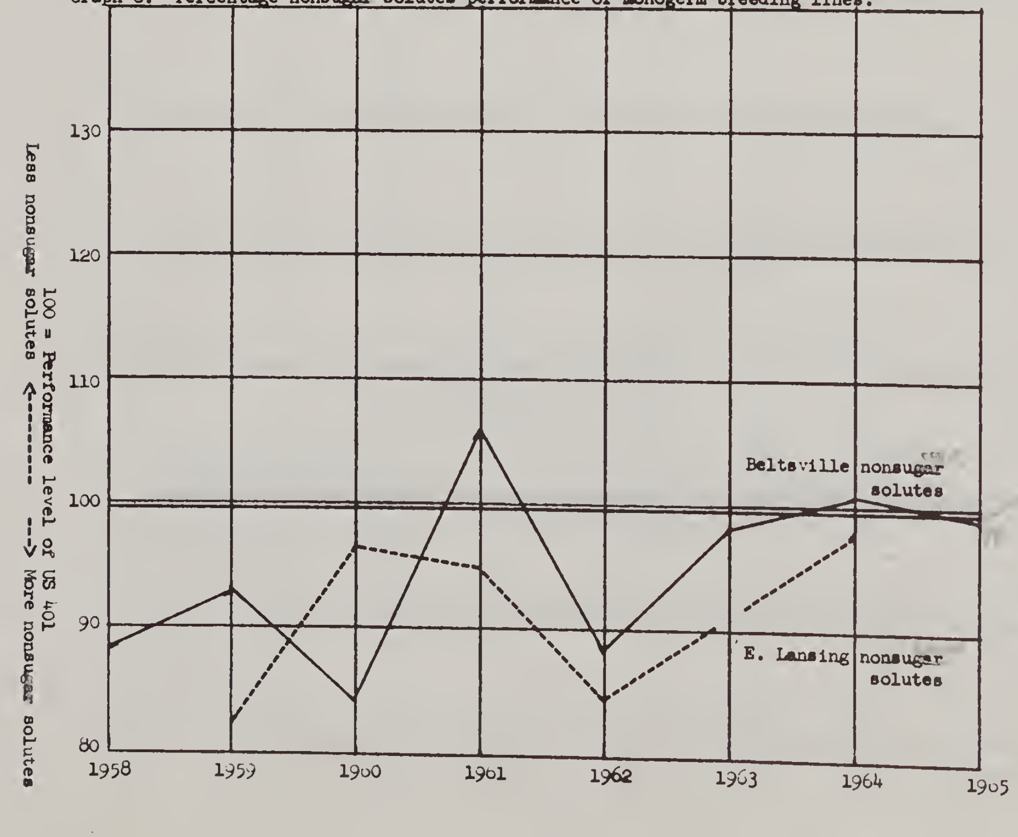
Graph 6. Sugar percentage performance of monogerm breeding lines.



Graph 7. Percentage nonsugar solutes performance of multigerm breeding lines.



Graph 8. Percentage nonsugar solutes performance of monogerm breeding lines.



Leaf Spot Tolerance of New O-Type Lines

Several new, apparently O-type, lines were found in 1965. To test their tolerance to Cercospora leaf spot, they were started in the greenhouse and transplanted to the nursery. Leaf spot readings are presented in Table 1.

Table 1.--Leaf Spot Readings of New O-Type and Male-Sterile Companion Lines in the 1965 Leaf Spot Nursery, Beltsville, Md.

Seed number	Pollen fertile	Male sterile	Seed type	Leaf spot[1/] reading
SP 6440.	X		Segregating F_2 progeny	3.5
SP 6440-1		X	" "	4.0
SP 6442.	X		" F_2 "	3.5
SP 6442-1		X	" "	4.0
SP 6443.	X		" F_2 "	3.0
SP 6468-01	X		" " "	4.0
SP 6468-1		X	" "	3.0
SP 6464-01	X		monogerm	4.0
SP 643301.	X		"	3.0
SP 643301-1		X	"	3.5
SP 643448.	X		"	2.5
SP 643448-2		X	"	2.0
SP 643450.	X		"	5.0
SP 643450-1		X	"	5.0
SP 643453.	X		"	6.0
SP 643454.	X		"	5.0
SP 643454-1		X	"	4.5
SP 643456.	X		"	4.0
SP 643456-1		X	"	4.0
SP 643465.	X		"	2.0
SP 643465-1		X	"	4.0
SP 643474.	X		"	5.0
SP 643474-1		X	"	4.0
SP 6423-0	X		"	4.0
SP 65209-0	X		"	3.5
Check Varieties (Not O-Type)				
US 401	X		multigerm	4.0
SP 6322-0	X		"	2.5
Susceptible check	X		"	6.0

1/ 0 = No leaf spot; 10 = All leaves dead.

It is encouraging that two among the new O-type monogerm lines (SP 643448. and SP 643465.) have leaf spot tolerance equal to that of SP 6322-0 and that only four are as susceptible as US 401. This level of tolerance is higher than that previously attained in monogerm O-types originating at Beltsville. The vigor of these lines appears to be good for inbred sorts.

Zoospore Production for Greenhouse Black Root Tests

To produce inoculum for greenhouse black root tests, mycelial mats of *Aphanomyces cochlioides* are grown in .3% soytone broth under sterile conditions. Zoospores are produced from these mats by washing them in sterile water and transferring them to sterile water in Fernbach flasks. One and one-half ml of 10% Nacl solution and a small quantity of a buffering salt (pH 6.8) are added to each flask to increase zoospore production. Within 12 hours, zoospores are produced in abundance. It is difficult to maintain sterile conditions after the mycelial mats are removed from the .3% soytone broth. Indeed, sterile conditions for this portion of the procedure were thought unnecessary and were not attempted. After using the Fernbach flasks 5 or 6 times, it had been noticed that zoospore production began to decrease. This was attributed formerly to the accumulation of "staling" products on the sides of the flask, and a good washing with soap and water seemed to restore zoospore production. Recently, however, washing the flasks has not appeared to help. It was then discovered that bacteria were attacking the zoospores, causing them to lyse. The bacteria were attacking the mycelial mats also. To remedy the situation, the Fernbach flasks and all the utensils used in handling the mats were autoclaved. Although aseptic conditions are not completely maintained after removal of the mycelial mats from the soytone broth culture, very few bacteria are present when zoospore production begins. The results has been a threefold increase in number of zoospores available for inoculations.

The thought has occurred that it might be possible to control *Aphanomyces cochlioides* by introducing this particular zoospore lysing bacteria into the soil along with sugarbeet seed. This idea has not been tested experimentally.

Spray Test for the Control of Cercospora Leaf Spot

A spraying experiment to control Cercospora leaf spot was conducted in 1965 to determine the production loss caused by leaf spot in our commercial type multigerm leaf spot resistant variety, SP 6322-0, and how this loss compared with losses in US 401 and the susceptible check variety, SP 633269-0. A randomized block split-plot design with six replications was used. Each replication in both halves of the split-plot was surrounded by a border of SP 6322-0 to minimize the effect of drifting inoculum and spray. Plants in half of the split-plots received 11 mist spray applications of copper oxychloride at the rate of 3/4 pound per acre to control the disease. When it rained, the fungicide was applied the next day. Otherwise, it was applied at weekly intervals. Plants in the other half of the split-plots were inoculated with *Cercospora beticola* and were not sprayed with the fungicide. Leaf spot evaluations were made on July 23, July 30, August 6, August 12, and September 4. The two center rows of sugarbeets in each replication of each variety were harvested October 6, weighed, and analyzed for percent sucrose and percent total solids in the raw juice.

The fungicide spray treatment only partially controlled leaf spot. If it had been completely controlled, the results undoubtedly would have been of even higher significance. Leaf spot ratings were made on a scale of 0 to 10 (0 being no spots on any of the leaves; and 10, all leaves dead from leaf spot). The average leaf spot ratings of the sugarbeets in all six replications are presented in Table 2.

Table 2.--Average leaf spot readings of three sugarbeet varieties in 1965 spray test. Plant Industry Station, Beltsville, Md.

Variety	Treatment	Average Leaf Spot Readings				
		July 23	July 30	Aug. 6	Aug. 12	Sept. 4
SP 633269-0	No spray	4.50	4.83	5.08	5.17	6.33
	Sprayed	1.42	2.00	2.83	2,92	5.00
	Difference	3.08	2.83	2.25	2.25	1.33
US 401	No spray	3.08	3.83	4.08	4.08	4.50
	Sprayed	1.00	1.83	1.92	2.17	3.75
	Difference	2.08	2.00	2.16	1.91	0.75
SP 6322-0	No spray	2.08	2.25	3.00	3.00	3.42
	Sprayed	0.42	1.25	1.25	1.42	2.67
	Difference	1.66	1.00	1.75	1.58	0.75
LSD:						
For Varieties	(5% level)	.23	.22	.28	.26	.31
	(1% level)	.31	.30	.37	.35	.42
Treatments	(5% level)	.33	.39	.26	.29	.38
	(1% level)	.51	.62	.41	.46	.59
V X T	(5% level)	.46	.44	NS	.52	
	(1% level)	.61	.59		NS	NS

The varieties had highly significant differences in the amount of leaf spot present. The plants in plots sprayed with fungicide had less leaf spot than those in unsprayed plots. This also was highly significant. The magnitude of the difference in leaf spot ratings between plants in plots sprayed with fungicide and those in unsprayed plots was greatest for SP 633269-0 and least for SP 6322-0. This difference in magnitude was highly significant for the leaf spot evaluations made July 23 and July 30. It was significant at the 5% level for those made on August 12 but below the level of significance for those made on August 6 and September 4. The decrease in significance in the later readings is related to the progressive decline in magnitude of the differences in readings between the plants in the plots sprayed with fungicide and those in unsprayed plots.

When all the leaf spot evaluation data are considered, it is reasonable to state that fungicide spraying does not protect and improve more tolerant varieties as much as it protects and improves those that are less tolerant. This statement should not be confused with the amount of leaf spot present on plants in sprayed plots of more tolerant varieties as compared to plants in sprayed plots of less tolerant varieties. Sprayed plants of tolerant varieties have appreciably less leaf spot than those of more susceptible varieties. It merely means that when a variety with sufficient leaf spot resistance is available, it will not be economically feasible to spray for leaf spot control. Some of the new experimental varieties and hybrids have this degree of tolerance for the moderately severe epidemics that ordinarily occur in the Great Lakes area. However, they need extensive field testing to determine if they are as productive as some of the less tolerant hybrids where leaf spot is absent or mild. Harvest data for the spraying test are presented in Table 3.

Table 3.--Harvest data of 1965 sugarbeet field test conducted under conditions of severe leaf spot exposure. Beltsville, Md. (Data are averages of six replications.)

		Acre Yield			Raw Juice	
Variety	Treatment	Gross sugar	Roots	Sucrose	Apparent purity	Nonsugar solutes
		lbs.	tons	%	%	%
SP 633269-0	Sprayed	4033	17.86	11.29	75.25	3.57
	No spray	2395	12.63	9.48	72.59	3.70
	Difference	1638	5.23	1.81	2.66	-.13
US 401	Sprayed	6015	24.39	12.33	78.28	3.50
	No spray	4030	18.57	10.85	75.60	3.43
	Difference	1985	5.82	1.48	2.68	+.07
SP 6322-0	Sprayed	6620	25.21	13.13	80.18	3.27
	No spray	5444	21.67	12.56	79.36	3.25
	Difference	1176	3.54	.57	.82	+.02
LSD:						
Varieties	(5% level)	277	1.27	.39	1.21	.17
	(1% level)	375	1.73	.53	1.63	.23
Treatments	(5% level)	515	2.36	.17	1.31	NS
	(1% level)	809	3.71	.27	2.06	
V X T	(5% level)	509	NS	.78	NS	NS
	(1% level)	690		1.05		

One can examine the harvest data and determine: a) the effect of the treatments, b) the differences among varieties within treatments, and c) the variety-treatment interaction.

a) <u>The effect of the treatments</u>.--There were highly significant differences between the sprayed and unsprayed sugarbeets in percent sucrose and in gross sugar per acre. There were significant differences between sugarbeets from the two treatments in root yield. These differences were significant at the 1% level in the susceptible check and US 401 but only at the 2% level for SP 6322-0. There was a highly significant difference in raw juice apparent purity between sprayed and unsprayed sugarbeets for the susceptible check and US 401, which was caused by the large difference in percent sucrose. There was no significant difference in raw juice apparent purity of sugarbeets of SP 6322-0 from the two treatments.

b) <u>Differences between varieties within treatments</u>.--There were highly significant differences between varieties in percent sucrose, gross sugar per acre, and percent raw juice apparent purity. Except for the sprayed sugarbeets of US 401 and SP 6322-0, there were also highly significant differences between varieties in root yield. SP 6322-0 contained significantly less nonsugar solutes in the raw juice than did the two other varieties. This is the result of having specifically selected for this characteristic during the genesis of SP 6322-0.

c) <u>Variety X Treatment interaction</u>.--The difference between the sprayed and unsprayed sugarbeets of SP 6322-0 in percent sucrose was significantly less than the difference between sprayed and unsprayed sugarbeets of each of the other two varieties. US 401 and SP 633269-0 did not differ significantly from each other in this respect. The amount of difference between sprayed and unsprayed sugarbeets of SP 6322-0 in gross sugar production was significantly less (at the 1% level) than the difference between sprayed and unsprayed sugarbeets of each of the other two varieties. This difference for SP 633269-0 was less than that for US 401, which is the reverse of what was expected according to their relative degrees of leaf spot tolerance. There were probably several factors contributing to this result. The sprayed plants of SP 633269-0 did not yield as much as they should have, because leaf spot was severe enough to cause appreciable losses. SP 633269-0 has never produced well at Beltsville, because it has little or no resistance to root rotting diseases. Hence, the full potential of SP 633269-0 cannot be realized at Beltsville.

Considering all the harvest data from this spray test, it can be stated that leaf spot causes a smaller production loss in the tolerant variety, SP 6322-0, than in the more susceptible varieties. The amount of loss is related to the degree of leaf spot tolerance of the variety.